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IMPRIMERIE A/S L. IHRICH

Wilhelm Walter Otto Mielck.

(1878—1933).

PROFESSOR, DR. PHIL. WILHELM W. O. MIELCK starb am 5. Oktober 1933 an den Folgen eines Schlaganfalls, welcher ihn in seinem Dienstzimmer in der Biologischen Anstalt auf Helgoland überraschte.

Wie ein schwerer Schlag traf uns die Nachricht von dem plötzlichen Tod des noch nicht 55 Jahre alten, so lebensfroh und so gesund aussehenden Mannes. Allzu früh wurde M i e l c k der Wissenschaft, seinen Mitarbeitern und seiner Familie entrissen. Die Früchte seiner langjährigen, gewissenhaften

Forschungsarbeiten sollte er nicht mehr ernten, den vollständigen Ausbau der Biologischen Anstalt, deren heutige Gestalt wir seiner Tatkraft verdanken, sollte er nicht mehr erleben.

W. Mielck entstammt einer alten Hamburger Familie und wurde am 24. November 1878 als Sohn des Apothekenbesitzers Dr. phil. J. B. Mielck zu Hamburg geboren. Er besuchte dort die Gelehrtenschule des Johanneums, später das Gymnasium in Wismar. Durch ein Halsleiden war Mielck veranlasst, so oft er konnte, die See aufzusuchen. Von Hause aus bekam er die Vorliebe für Biologie mit. So war es natürlich, dass er sich diesem Fach widmete.

Er besuchte die Hochschulen Göttingen und Strassburg und schloss seine Studien an der Meeresuniversität Kiel als Schüler von Brandt mit einer Dissertation über Radiolarien ab. Diese Untersuchungen erstreckten sich auch auf pazifische Acanthometren. Es gelang Mielck, eine klare systematische Einteilung der Familien und Arten aufzustellen und verschiedene Angaben früherer Forscher zu berichtigen. Die genaue Darstellung der Stachelverbindungen verdient unsere Bewunderung und zeigt Mielck bereits als den bis ins Kleinste exakten Forscher (1, 2).

Schon seit Mai 1906 war Mielck Assistent am Kieler Laboratorium für die Internationale Meeresforschung. Als solcher machte er mehrere von Apstein geleitete Terminfahrten mit und nahm an der Bearbeitung der Planktonfänge (3) teil. Seitdem wurde er für die Beobachtung des lebenden Planktons begeistert. Die Untersuchungen an Radiolarien setzte Mielck später bei allen Poseidonfahrten fort, sowie er nur Zeit dafür erübrigen konnte. Als Frucht dieser Beobachtungen erschien 1912 eine Arbeit über die Tripylee *Phaeocolla pygmaea* (4) und 1913 eine Zusammenstellung über die nordischen Heliozoen und Radiolarien (5). Hierin wurden die Ergebnisse der Terminfahrten dargestellt und die Beziehungen der Verbreitung und Massenentfaltung zur Hydrographie und den Jahreszeiten hervorgehoben. Eine grosse Menge von noch nicht ausgewerteten sorgfältigen Aufzeichnungen, die für die Bearbeitung der Radiolarien in der "Tierwelt der Nord- und Ostsee" benutzt werden sollten, geben Zeugnis für das dauernde Interesse Mielcks für diese Gruppe.

Die allgemeinen, systematischen und phänologischen Planktonstudien setzte Mielck auf Helgoland fort, als er am 1. Nov. 1907 eine Assistentenstelle an der Biologischen

Anstalt übernahm. An diesem klassischen Ort der Planktonforschung beobachtete er mehrere Jahre lang täglich die lebenden Fänge und legte ausführliche Listen an, welche einer späteren zusammenfassenden Darstellung dienen sollten. Eine grosse Anzahl von Forschungsfahrten bot willkommene Gelegenheit, die Helgoländer Beobachtungen zu ergänzen und auszubauen. Stets hat Mielck darnach gestrebt, die ökologischen Zusammenhänge zu erforschen, Schlüsse zu ziehen von der Zusammensetzung des Planktons auf die Strömungen und die Wasserbeschaffenheit. Oft konnte er den Ozeanographen wertvolle Aufklärung oder Bestätigung geben, wenn es sich darum handelte, die Herkunft der Wassermassen zu bestimmen. Mit grösster Freigebigkeit stellte Mielck die erworbenen Kenntnisse seinen Mitarbeitern und Schülern zu Verfügung. Viele im engeren Kreise abgehaltenen Planktonkurse und später das grosse, seit 1920 alle 2 Jahre wiederholte Planktonkolleg im Rahmen des meeresbiologischen Praktikums werden allen Teilnehmern in dankbarer Erinnerung bleiben. Ich darf hoffen, dass es den Helgoländer Planktonforschern gelingt, noch manche wertvolle Schätze aus den Mielck'schen Aufzeichnungen zu heben.

Die fischereibiologischen Arbeiten Mielcks waren zunächst eng verknüpft mit seinen Planktonstudien. Zusammen mit Ehrenbaum beteiligte er sich an den Untersuchungen über die pelagische Fischbrut der Deutschen Bucht (9). Dann bildete besonders die Nahrung der Fischlarven ein Spezialgebiet (10, 11), bei dem ihm seine Kenntnis der kleinen pflanzlichen und tierischen Planktonten zustatten kann.

1909 war Mielck in den Anstaltsdienst übergetreten und 1910 wurde er als Kustos für Seefischerei der Nachfolger von Professor Ehrenbaum. In die folgende Zeit fallen eine ganze Reihe von Untersuchungsfahrten, welche von Mielck geleitet wurden, darunter eine grössere Fahrt des "Poseidon" nach dem Barentsmeer (Juni u. Juli 1913). Die über diese Fahrt veröffentlichten Berichte (13, 14) zeigen, wie vielseitig die Beobachtungen Mielcks waren und wie es ihm gelang, den Erfolg der Fahrt trotz der ungünstigen Jahreszeit zu erreichen. Hier schenkte Mielck auch den "Beifangtieren" der grossen Kurre seine Aufmerksamkeit. Bei allen späteren Fahrten der Biologischen Anstalt hat er veranlasst, dass diese Beifänge sorgfältig aufgezeichnet und zusammengestellt wurden. Ein zusammen mit Hertling verfasstes Manuskript mit einer Karte "Fischfangplätze und Bodenfauna" wurde der internationalen Kommission 1931 vorgelegt. Die ökologischen

Bemerkungen zu den Arbeiten über die Ascidien (14b), Echinodermen (14 c) und Hydroiden (14 d) zeigen, dass er auch der Bodenfauna Interesse entgegenbrachte, sodass er die von der Anstalt begonnenen Boden- und Bodentieruntersuchungen wesentlich fördern konnte (23).

Die Kriegs- und Nachkriegszeit brachten für Mielck besondere Aufgaben. Als Reserveoffizier und Adjutant des Kommandanten der Festung Helgoland war er nach der Räumung der einzige Anstaltsbeamte, welcher während des Krieges auf der Insel bleiben konnte und einige der laufenden wissenschaftlichen Untersuchungen weiterführen konnte. Gleichzeitig hatte er eine kleine Fischerei mit dem Anstaltsfahrzeug eingerichtet, die wesentlich zur Erleichterung der Ernährung von Besatzung und Zivilbevölkerung beitrug (18).

Bei den Verhandlungen des Unterausschusses zur Schleifung der Festung Helgoland war Mielck als Beauftragter des Ministeriums tätig und erreichte zusammen mit Geheimrat Heincke durch sein mannhaftes Einsetzen für die Belange der Insel und der Anstalt, dass solche Gebäude, welche gemeinnützigen friedlichen Zwecken dienen konnten, nicht zerstört wurden, und dass ein Teil der Molen zum Schutze der Düne stehen bleiben durfte (17).

Auch in den späteren Jahren hat es Mielck trotz seiner Überlastung mit so vielerlei beruflichen Arbeiten stets als seine Pflicht angesehen, für gemeinnützige Ziele einzutreten und z. B. den Badeverkehr und die Arbeiten der Deutschen Gesellschaft zur Rettung Schiffsbrüchiger erfolgreich zu fördern.

Gleich nach dem Kriege gelang es Heincke, die Wiederaufnahme der Fischereiuntersuchungen durchzusetzen. Mielck leitete die zahlreichen 1919 und 1920 ausgeführten Fahrten mit grosser Hingabe (20) und verschaffte Heincke das Material für die Untersuchungen über die Wirkung der Kriegsschonzeit.

Am 1. April 1921 wurde Mielck als Nachfolger von Fr. Heincke zum Direktor der Biologischen Anstalt ernannt. Gleichzeitig wurde er Mitglied der Deutschen Wissenschaftlichen Kommission für Meeresforschung. In dieser Eigenschaft leitete er zusammen mit dem greisen Altmeister der deutschen Fischereibiologie, Heincke, die Untersuchungen über den Nutzfischbestand der Nordsee. Er nahm Stellung zu den internationalen Plänen für Schonzeiten und Schonreviere an der Festlandsküste (16) und leitete die dafür nötige eingehende fischereiliche Untersuchung der Deutschen Bucht. In den Jahren 1923 bis 1933 wurden 10

Poseidonfahrten in dies Gebiet nach Mielcks Plänen und meist unter seiner Leitung ausgeführt. Er legte ein engmaschiges Netz von Untersuchungsstationen fest, die periodisch aufgesucht wurden. Diese verbesserte Arbeitsweise erwies sich als ausserordentlich fruchtbar z. B. für die Verfolgung der jahreszeitlichen Wanderungen der Fische und vor allem der Schwankungen und Veränderungen des Nutzfischbestandes.

Als Deutschland sich im September 1926 wieder der Internationalen Meeresforschung anschloss, wurde Mielck zum deutschen Delegierten ernannt; 1928 wurde er zum Vorsitzenden der Kommission für die südliche Nordsee gewählt und verwaltete dieses Amt bis zu seinem Tode. Es ist vielen Lesern dieser Zeitschrift bekannt, mit welcher Gründlichkeit und mit welcher Hingabe er sich den Aufgaben der Internationalen Meeresforschung widmete und wie Mielck überall geachtet und beliebt war. Die jährlichen Berichte (34—38) in den Rapports Administratifs (1929—1933) enthalten klare Übersichten der Arbeiten seines Gebietes. Wir hoffen, dass seine Anregungen zur gemeinsamen Forschungsarbeit noch reiche Früchte tragen werden.

Die letzten Arbeiten Mielcks bezogen sich auf Fischbrut- und Planktonuntersuchungen in der Ostsee und auf die Heringsbrut der südlichen Nordsee (12).

Über die Ostseearbeiten liegt ein fertiges Manuskript vor, welches wertvolle Ausführungen über die Methodik der Fischbrutuntersuchungen an Bord enthält.

Auch über die Fischbrut in der Nordsee hat Mielck umfangreiches Material gesammelt, dessen Bearbeitung bereits mit grösster Gründlichkeit vorbereitet war, sodass wir auch hier hoffen dürfen, vieles von den reichen Schätzen seiner Kenntnis zu retten. Insbesondere legte er grosses Gewicht auf die Untersuchung der Brutverhältnisse des Herings in der südlichen Nordsee. Immer wieder hat er darauf hingewiesen, dass diese Verhältnisse noch beiweitem nicht genügend geklärt wären, dass dies aber die wichtige Grundlage für die Frage der sogenannten Heringsrassen in diesem Gebiet wie für die Beurteilung der Herkunft der Jungheringe an den Nordseeküsten sei. Er hat sich lebhaft und mit Erfolg bemüht, eine internationale Zusammenarbeit zur Lösung dieser Fragen unter Anwendung geeigneter Fangmethoden zu bringen. Sein eigenes, auf verschiedenen Fahrten des "Poseidon", der "Weser" und der "Augusta" gesammeltes Material hat er zum grössten Teil bereits eingehend bearbeitet, sodass wesentliche Ergebnisse schon zu erkennen sind.

Als Direktor der Preussischen Biologischen Anstalt hat Prof. M i e l c k in den Jahren 1921—1933 ein grosses Mass von organisatorischer Arbeit geleistet. Die Anstalt hatte durch den Krieg sehr gelitten. Obwohl ein Neubau schon 1910 geplant war, befanden sich die Laboratorien noch in unzulänglichen Räumen von 4 alten Wohnhäusern, nur das 1902 errichtete Aquarium bot den Gästen einige moderne Arbeitsplätze. Wir verdanken es der umsichtigen und rastlosen Arbeit von M i e l c k, dass sich das Institut trotz der schwierigen Verhältnisse nach dem Kriege stetig weiterentwickelte. Nach seinen sorgfältig bis ins Kleinste ausgearbeiteten Plänen entstand allmählich der jetzige gewaltige Bau, welcher in der einen Hälfte das moderne neue Schauaquarium mit den nötigen Betriebsräumen und Laboratorien der Beamten enthält, dessen zweiter, 1929 im Rohbau fertiggestellter Teil aber noch nicht ganz eingerichtet ist. Nur die Vollendung der Räume für die wertvolle Anstaltsbibliothek konnte M i e l c k noch erleben. Lange Jahre hat er diese Bibliothek selbst verwaltet und sie stets gefördert. Bau und Einrichtung des 1927 eröffneten neuen Aquariums wurden von M i e l c k 1925 auf einer längeren Reise vorbereitet, welche ihn nach Neapel, Amsterdam, Plymouth und London führte. Bis in die Einzelheiten der Beckenausstattung schenkte er der neuen Einrichtung seine Aufmerksamkeit und das Helgoländer Aquarium bildet die Freude aller Fachgelehrten und Naturfreunde, welche die Insel alljährlich im Sommer besuchen. Namentlich der Algenschmuck zeichnet es vor anderen Aquarien aus.

Die 1920 mit ganz einfachen Mitteln von der Anstalt begonnenen Lehrkurse wurden unter M i e l c k ' s Leitung weiter ausgebaut und erfreuten sich eines grossen Zuspruchs seitens der Studierenden. Persönlich beteiligte sich M i e l c k an dem grossen meeresbiologischen Praktikum für Fortgeschrittene mit seinem Planktonkolleg, das mit Ausgabe von sehr vielen schönen Präparaten verbunden war. Die Plätze für selbständige Arbeiten von Forschern, Studierenden und Lehrern waren reich besucht. Insgesamt wurde die Anstalt in den letzten Sommern von durchschnittlich 300 Gästen besucht. In vielen Fällen ermöglichte M i e l c k jüngeren Gelehrten die Arbeit am Meer. Auch auf Grenz- und Nachbargebieten der Meeresbiologie gelegene Untersuchungen hydrographischer, geologischer und meteorologischer Art wurden von ihm tatkräftig gefördert. Der Versand von zoologischem und botanischem Untersuchungsmaterial an Universitätsinstitute und Schulen aller Art hat sich gegenüber der Zeit vor dem Kriege etwa

verdreifacht. Die neu eingerichtete ornithologische Abteilung, die Vogelwarte, hat sich infolge der ihr von Mielck gewidmeten Fürsorge zu einem der leistungsfähigsten Institute auf diesem Gebiet entwickeln können. An der Biologischen Anstalt arbeiteten in den letzten Jahren ständig 10—12 Gelehrte. Mielck hat es verstanden, sich auf dem Gebiet der Meeresforschung einen Stab von Mitarbeitern auszubilden, welche seine Arbeiten in seinem Sinne weiterzuführen bestrebt sind. Das praktische Ziel seiner Forschungsarbeit war die Förderung der Seefischerei und die Verbreitung der Kenntnis vom Meere unter den Volksgenossen. Seine Arbeitsmethoden waren streng wissenschaftlich und genau; grossen Hypothesen und grossen Worten abhold hielt er es für seine und seiner Mitarbeiter Pflicht, erst gewissenhaft einwandfreies Tatsachenmaterial zu sammeln. Daher auch seine Begeisterung für die Forschungsfahrten, die ihm zugleich willkommene Pausen der überreichen Verwaltungsarbeit boten. Doch war er dabei Tag und Nacht tätig. Waren die übrigen Fahrtteilnehmer schon zur Ruhe gegangen, so sass Prof. Mielck noch an seinem Mikroskop und beobachtete das feine Plankton. In einer ruhigeren späteren Zeit sollten die vielen Notizen und Zeichnungen ausgewertet werden. Es kam anders, dem reichen und tätigen Forscherleben hat das Schicksal ein jähes Ende bereitet.

Die stets hilfsbereite und liebenswürdige Persönlichkeit des vielbeschäftigten Gelehrten und welterfahrenen Mannes erwarb sich überall Achtung und Dankbarkeit. Als Vorgesetzter war er auch für den kleinsten Angestellten ein väterlicher Freund und Helfer in beruflichen und privaten Nöten. Nur jeweils wenige Tage zwischen seiner Arbeit gönnte er sich Erholung, bei der er sich ganz seiner Familie widmete, der treubesorgten Gattin und dem heranwachsendem Sohne. Dann wurden Fusswanderungen an den Ufern der Elbe oder in den holsteinischen Wäldern ausgeführt. Mielck zeigte dann seine Begeisterung für die Schönheiten der Natur. Mit sonnigem Humor begabt war er bei seinen Freunden hoch geschätzt, und an fröhliche Stunden in seinem gastfreien Hause wird sich so mancher Kollege und Freund immer gerne erinnern. Wenige Monate nach seiner silbernen Hochzeit sollte auch das häusliche Glück für immer gestört sein.

Dem Forscher und Organisator, dem warmherzigen Freund und Führer werden seine Freunde und Mitarbeiter stets ein ehrendes Andenken bewahren.

A. H.

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Report on the Free Ammonia, Albuminoid Nitrogen and Organic Nitrogen in the Waters of the Puget Sound Area, during the Summers of 1931 and 1932.

By

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Introduction.

Ammonia has been determined in sea water by many investigators because of its connection with the marine nitrogen cycle. In all the earlier work, the ammonia was determined by distillation with subsequent nesslerization, a method open to objection due to the partial decomposition of organic material under the influence of heat and the added alkali. More recently, two methods have been developed which make possible the direct determination of ammonia in sea water. In one method (Witting-Buch, [5, 16]) the ions interfering with the Nessler reaction are precipitated and the determination made on the supernatant liquid. In the other method (Wattenberg, [13]) the interfering ions are held in solution by means of tartaric acid or Rochelle salt.

Along with the ammonia determination a few authors have also determined albuminoid nitrogen (so-called) by the well-known method of Wanklyn, Chapman and Smith (12). In this method the residue from the ammonia determination is treated with alkaline permanganate and the nitrogen, split out of the organic material as ammonia, distilled over and determined by nesslerization. Some of the results so obtained by various investigators are summarized in Table I.

Results of organic nitrogen determinations on sea water, other than albuminoid nitrogen, have not been reported, to the knowledge of the authors. Gad-Andresen (6) describes a Kjeldahl method in connection with his gasvolumetric methods for ammonia, nitrite and nitrate, and Giral (7) suggests the use of the same method in the determination of total nitrogen.

Methods of Determination.

Free ammonia: The method of Wattenberg for the direct estimation of ammonia in sea water was used. It requires the following reagents:

A. Thirty per cent. Rochelle salt solution. Three hundred grams of Rochelle salt are added to a liter of water. A little sodium hydroxide is added and about three hundred milliliters of water removed by evaporation. This removes any ammonia from the reagent.

B. Nine normal sodium hydroxide solution. About one and one quarter times as much water as necessary is added to the solid compound and the excess removed by evaporation.

C. Nessler's reagent. In 1931 reagents were made up according to the directions given in Treadwell and Hall (11) and in "Standard Methods of Water Analysis" (10). At this time only the Treadwell reagent was found to be usable in the direct determinations on sea water, since the other invariably gave a turbidity. When the same Nessler reagents were tried after having stood for a year, only the "Water Analysis" reagent gave good results.

Procedure: To one hundred milliliters of sea water contained in

Table I.

Results of free ammonia and albuminoid nitrogen determinations made on sea water by previous investigators.

Investigator	Date	Locality	NH_3-N Mg./m³	Alb.-N Mg./m³	Reference	Method
Natterer	1890—96	Med., Red Sea	40	103	3	Distil.
Vernon	1899	Coast off Naples	15	66	3	„
Nathansohn	1906?	Christianiafjord	18	128	3	„
Raben	1904—05	North Sea	42	126	3	„
	1906	„	66		3	„
	1911—14	„		126	3	
	1911—14	Skagerrak and Kattegat		280	3	
	1911	Baltic Sea		126	3	
Sundry Authors		North Sea	30—66		3	„
		Baltic Sea	21—66		3	„
Ringer-Klingen	1906—07	North Sea	64		3	„
Gräf		"Planet" Exped.	48		3	„
Gebbing		"Gauss" Exped.	58		3	„
Raben		Spitzbergen	92—95		3	„
		Barents Sea	48—72		3	„
Brujewicz	1929	Barents Sea	4—20[1])	30—60[1])	4	„
Buch	1915—19	Baltic Sea	10—50		3	Witting
Ruud	1929—30	Weddell Sea	19		8	„
Braarud, Klem	1930	Norwegian Coast	22		2	„
Wattenberg	1929	Irming Sea	5—25		14	Wattenberg
Seiwell	1930	Coast of Maine	0—350[1])		9	„
Bini	1929	Red Sea	90—500[1])		1	„

[1]) Indicates range of values, rather than average value, as is the case with the other data.

a Nessler tube are added in succession two and one half milliliters of Rochelle salt solution, eight milliliters of sodium hydroxide solution and two milliliters of Nessler's reagent, allowing thorough mixing to take place between each addition. Shaking is unnecessary, as the greater densities of the added solutions automatically stir the solutions. After fifteen or twenty minutes comparison is made visually with standards treated in the same manner.

Wattenberg recommends the use of five milliliters of thirty per cent. Rochelle salt solution; but in the waters investigated by the authors such a high concentration invariably produced a turbidity on the addition of the Nessler reagent. Concentrations between two and three milliliters gave the best results. The amount of sodium hydroxide added can be varied between four and ten milliliters without appreciable differences being noticed.

Wattenberg also recommends adding the sea water plus the Rochelle salt to the sodium hydroxide solution, but repeated attempts using this method gave no better results than the more convenient procedure mentioned above. In no case, while working in the shore laboraty, were completely clear solutions obtained, but about ninety per cent. of the samples tested on board ship one half hour after being collected gave satisfactory results in this regard. Also, as added evidence of the importance of immediate nesslerization, water which had stood for more than one day usually gave a turbidity.

No sample of ammonia-free sea water prepared according to the directions of Wattenberg gave so clear a solution as a fresh sample of sea water. This observation has also been made by Braarud and Klem (2) who were unable to prepare satisfactory standards from the water of the Norwegian coast. It may have been that the decomposition products of plankton which are usually so abundant in such water caused the difficulty. For this reason fresh standards were prepared each time from the surface water which was in most cases ammonia-free. Experience showed that as little as two thousandths of a milligram of ammonia nitrogen in one hundred milliliters could be detected in this manner. To verify its absence in this water ammonia-free distilled water plus two milliliters of Nessler's reagent was used as the primary standard.

Albuminoid nitrogen: The method as outlined in "Standard Methods of Water Analysis" (10) was used. This procedure was first recommended by Wanklyn, Chapman and Smith (12) and has since been used by all investigators of this form of nitrogen.

Reagent: Alkaline permanganate, containing eight grams of potassium permanganate and four hundred milliliters of nine normal sodium hydroxide per liter.

On some of the first samples, the "free" ammonia was first distilled without the addition of any reagent, then alkaline permanganate added and the albuminoid nitrogen distilled as ammonia. The "free" ammonia thus determined gave variable and higher results than those obtained by direct nesslerization, as is evident from the data in Table

V (July 30th, 1932). The first distillation was therefore discontinued. In the revised method twenty-five milliliters of the alkaline permanganate solution were added directly to two hundred and fifty milliliters of unfiltered sea water, contained in an eight hundred milliliter Kjeldahl flask. About one hundred and seventy-five milliliters of the water were distilled through a block tin condenser and collected in a two hundred and fifty milliliter volumetric flask. Fifty milliliters of this distillate (after dilution to volume with ammonia-free water) were then nesslerized in a fifty milliliter Nessler tube. The color intensity developed after standing fifteen minutes was compared with permanent standards prepared according to the directions in "Standard Methods of Water Analysis". These permanent standards had been calibrated against solutions containing known amounts of ammonia in ammonia-free water. The free ammonia determined by direct nesslerization was subtracted from the apparent albuminoid nitrogen to give the true value. Duplicate analyses were made.

Organic Nitrogen: This quantity was determined by the well known Kjeldahl method, without the modifications necessary to permit the inclusion of nitrite and nitrate.

Procedure: Nine milliliters of concentrated, nitrogen-free sulfuric acid were added to a two hundred and fifty milliliter sample of unfiltered sea water contained in an eight hundred milliliter Kjeldahl flask, the water evaporated and the residue heated until sulfur trioxide was evolved copiously. The fused residue was allowed to partially cool, two hundred milliliters of ammonia-free distilled water and twenty to forty milliliters of nine normal sodium hydroxide were added, the ammonia distilled through a block tin condenser and determined as in the case of albuminoid nitrogen. The amount of free ammonia originally present was subtracted from the total to give organic nitrogen. A suitable correction for the ammonia in the reagents was necessary (usually amounting to 0.005 milligrams per fifty milliliters). This method was adopted instead of the alternative method of removing the free ammonia by evaporation before adding sulfuric acid as experiment showed that some ammonia was liberated from the organic material under these conditions. (See albuminoid nitrogen determination.) Check determinations were made in 1932, although this was not always the case in 1931. Five hundred milliliter samples were also used in the earlier work, but difficulties were encountered with the samples bumping. The use of two hundred and fifty milliliter samples did not completely overcome this difficulty, and at incipient crystallization vigorous rotation of the flask over the flame was always necessary to avoid complete loss of the sample.

Nine milliliters of concentrated sulfuric acid were used since this quantity was sufficient to completely replace all chlorides (with the formation of sodium bisulfate, for example) in the waters of highest chlorinity likely to be encountered and leave an excess of about two milliliters for the digestion. When insufficient sulfuric acid is used to completely form the bisulfate, loss of ammonia takes place on

fusion, as was determined in a series of control experiments. It is unnecessary to heat longer than indicated above as no increase in ammonia content was noticed even after fusing an additional twenty-five minutes. The quantity of sodium hydroxide added is sufficient to neutralize all the free acid and acid sulfate and leave an excess of alkali.

Results.

Besides the determinations reported in the tables below, one hundred and ninety-three free ammonia analyses were made between June 30th and July 7th, 1932, on a trip from Friday Harbor to the southern part of Puget Sound. Of these, one hundred and eighty-eight showed no ammonia (i.e. less than 0.02 milligrams, of ammonia nitrogen per liter), four showed 0.02 milligrams, and one 0.13 milligrams of ammonia nitrogen per liter. The one hundred and eighty-eight samples showing no ammonia were taken at the following depths: Surface, eighty-five samples; ten meters, thirty-one samples; twenty-five meters, twenty-five samples; fifty meters, twenty samples; one hundred meters, fifteen samples; one hundred and fifty meters, nine samples; and two hundred meters, three samples. Three of the samples containing 0.02 milligrams per liter were from one station off Foulweather Bluff at the entrance to Hood Canal, at depths of twenty-five, fifty, and one hundred meters. Only one surface sample showed ammonia. The sample containing 0.13 milligram was a bottom sample from East Sound.

A similar series of determinations were made during July and August, 1931, on the water in the Strait of Juan de Fuca (from San Juan Island to Cape Flattery) and in Haro Strait, the latter determinations being made by Mr. Harold Houlton. Fifty milliliter samples were used, but otherwise the determination was made as mentioned above, but using half quantities of reagents. Under these conditions the sensitivity of the determination was decreased slightly. Besides the two series reported in Table II, one hundred and one samples were analyzed, of which ninety-six showed no ammonia nitrogen, that is, less than 0.03 milligrams per liter. These

Table II.

Vertical distribution of ammonia at two stations in the Haro Strait. Values are milligrams of ammonia nitrogen per liter.

Depth Meters	1	10	25	50	100	200	400
Station 8, August 4, 1931	.0	.0	.0	.1	.06	.08	.4
Station 9, August 5, 1931	.0	.0	.03	.1	.1	.2	—

were distributed as follows: Surface, fifteen samples; ten meters, seventeen samples; twenty-five meters, seventeen samples; fifty meters, fifteen samples; one hundred meters, fifteen samples; one hundred and fifty meters, two samples; two hundred meters, nine samples; and

three hundred meters, six samples. Those showing 0.03 milligram per liter were from the surface (two samples) and one sample each from fifty, one hundred, and one hundred and fifty meters.

These two stations are at the northern end of San Juan Island, where the water was derived mostly from the Strait of Georgia and the Fraser River.

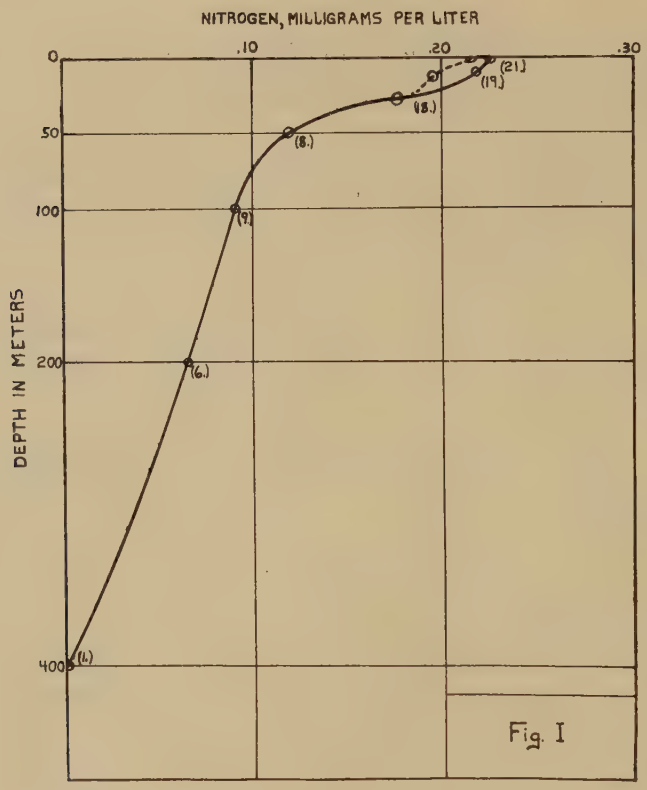

Fig. I. Average organic nitrogen content of the waters of the Puget Sound area. Dotted line indicates average taken, excluding the East Sound samples. Figures in parentheses are the number of samples taken to form the average.

Disregarding these two stations, the results show that the normal free ammonia content of the waters of the Puget Sound area is less than 0.02 milligram of nitrogen per liter. We do not find the vertical distribution noted by Wattenberg for the Danish Straits and Irming Sea, and in only three cases was 0.02 milligrams per liter found at the surface, as compared with an average content at the surface of 0.025 milligrams, as reported by Wattenberg. Our results

agree more closely with those of Braarud and Klem (2), who failed to find a vertical distribution of ammonia in the coastal waters off Møre and in the Romsdalsfjord. They used the method of Witting and Buch, adding a known quantity of ammonium chloride in order to bring the ammonia content of the sample above 0.06 milligrams per liter, where the linear relationship between concentration of ammonia and Nessler color first begins (Buch, [5]). The values thus obtained are probably more accurate for the lower concentrations than those reported here, so that their average (0.022

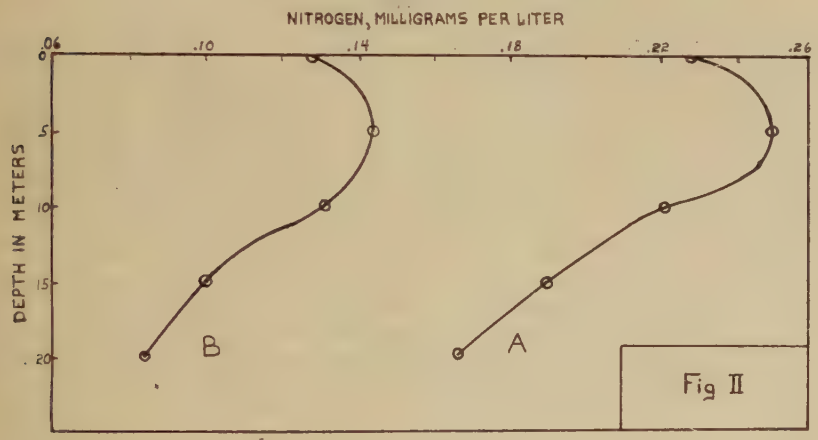

Fig. II. Average organic nitrogen content (curve A) and albuminoid nitrogen content (curve B) of the waters of East Sound. Forty-five samples are included in the average for albuminoid nitrogen, and forty-two in the average for organic nitrogen.

milligrams of ammonia nitrogen per liter) can be considered as being in agreement with our results.

Tables III, IV, and V give the results of the organic nitrogen and albuminoid nitrogen determinations, while Fig. I and II summarize these results. The maps (Fig. III and IV) show the location of the stations.

The chlorinity of the East Sound samples averaged about 16.6 $^0/_{00}$, with an average temperature of about 12 C. Of the other stations, Number 13 showed the lowest chlorinity and highest temperature encountered, 11.13 $^0/_{00}$ and 20.4° C. respectively. The maximum chlorinity (19 $^0/_{00}$) was found in the Strait of Juan de Fuca.

On those samples for which the values for both albuminoid and organic nitrogen were obtained, the average was 0.10 milligram per liter albuminoid nitrogen and 0.21 milligram per liter organic nitrogen. The value for the albuminoid nitrogen agrees very closely with those reported by other authors. The average ratio of albuminoid nitrogen

to organic nitrogen is 0.47, which is less than would be expected, although the permanganate oxidation is known to be incomplete. The great variation in the values of this ratio on different samples can probably be attributed to the fact that the form in which the organic nitrogen occurs varies from one sample to another. No regular

Table III.

Organic nitrogen, expressed as milligrams of nitrogen per liter, in samples taken during the year 1931.

Station Date Depth	1. July 7	2. July 7	3. July 8	4. July 11	3. July 11	5. July 12	6. July 12	7. Aug. 12
1 M	.18	.35	.15	.22	.20	.15	.20	.30
10 M	.05	.19	.23	.31	.19	.16	.21	.33
25 M	.17	.28	.00[1])	.37	.16	.15	.16	.10
50 M	.16	.19	.00	.25	.01	.00	.15	.22
100 M	.15	.00	.17	.19	.00	.00	.12	.28
150 M		.01	.17	.18	.00	.14		
200 M							.00	
400 M							.00	

1) The zero values in this table cannot be ascribed to the use of too little sulfuric acid for digestion, for in those cases where this did occur, negative values were obtained after subtraction of the blank on the reagents.

Table IV.

Organic nitrogen and albuminoid nitrogen, expressed as milligrams of nitrogen per liter, in samples taken in Hood Canal and south Puget Sound, during 1932.

Station	Date	Depth	NH_3	Alb.-N	Org.-N	Ratio	NO_2-N	NO_3-N
10	July 1	0 M	.00	.09	.16	.56	None	None
		25 M	.00	.08	.14	.57	.0041	.05
		100 M	.00	.03	.09	.33	.0034	.34
11	July 2	0 M	.00	.06	.12	.50	None	None
		50 M	.00	.01	.08	.12	„	.37
		100 M	.00	.01	.09	.11	„	.32
12	July 2	0 M	.00	.06	.16	.38	„	None
		10 M	.00	.18	.20	.90	„	.06
		20 M	.02	.17	.26	.65	„	.27
13	July 4	0 M	.00	.14	.22	.64	.0051	.09
		10 M	.00	.14	.19	.74	.0048	.09
		15 M	.00	.11	.22	.50	.0056	.10
14	July 4	0 M	.00	.22	.32	.69	Trace	Trace
		10 M	.00	.15	.31	.48	„	.03

The values for nitrite and nitrate in the tables were obtained by Dr. L. H. Evans, using the Ilosvay modification of the Griess method for nitrites and the Denigès-Harvey method for nitrates.

Table V.

Free ammonia, organic nitrogen and albuminoid nitrogen, expressed as milligrams of nitrogen per liter, in samples taken at East Sound, during 1931 and 1932.

Station	Depth	Free NH_3 Wattenberg		NH_3 Distil.	Albuminoid Nitrogen			Organic Nitrogen			Ratio Albuminoid / Organic		Nitrite Nitrogen $\times 10^2$			Nitrate Nitrogen		
		August 12, 1931	July 30, 1932	August 13, 1932	June 25, 1932	June 25, 1932	July 30, 1932	August 13, 1932	August 12, 1931	July 30, 1932	August 13, 1932	July 30, 1932	August 13, 1932	August 12, 1931	June 25, 1932	August 13, 1932	August 12, 1931	June 25, 1932	August 12, 1932
A	0 M	.00	.00	.07	.02	.30[1])	.08	.16	.21	.23	.34	.35	.47	.00	.40	.14	.00	.13	.07
	5 M	.00	.00	.00	.03	.29[1])	.12	.14	.17	.24	.31	.50	.45	.05	.36	.14	.07	.10	.09
	10 M	.02	.00	.00	.06	.17[1])	.11	.11	.19	.20	.22	.55	.50	.33	.40	.19	.08	.12	.12
	15 M		.00	.02	.05	.11[1])	.11	.09		.19	.18	.58	.50		.36	.29		.19	.17
	20 M	.07	.02	.04	.10	.13[1])	.10	.10	.15	.18	.20	.63	.50	.40	.30	.16	.14	.15	.25
B	0 M	.00	.00	.00	.05	.11[1])	.12	.04	.17	.24	.23	.50	.17	.00	.00	.18	.00	.00	.07
	5 M	.02	.00	.00	.01	.12[1])	.17	.08	.17	.30	.20	.57	.40	.41	.20	.00	.00	.12	.04
	10 M	.02	.00	.00	.02	.18[1])	.11	.07	.23	.24	.22	.46	.32	.42	.30	.21	.08	.17	.14
	15 M		.00	.00	.08	.15[1])	.08	.08		.16	.19	.50	.47		.36	.25		.24	.10
	20 M	.02	.00	.00	.08	.10[1])	.10	.06	.16	.15	.21	.67	.29	.43	.30	.29	.15	.21	.12
C	0 M	.00	.00	.00	.01	.08[1])	.12	.15	.17	.24	.23	.50	.65	.35	.00	.05	.11	.05	.07
	5 M	.00	.00	.00	.02	.18[1])	.10	.09	.18	.41	.27	.23	.33	.34	.18	.14	.15	.10	.13
	10 M	.00	.00	.00	.06	.17[1])	.14	.12	.16	.32	.19	.44	.63	.37	.20	.21	.21	.14	.24
	15 M		.00	.00	.01	.14[1])	.08	.05		.18	.18	.45	.28		.31	.27		.26	.15
	20 M	.00	.02	.00	.06	.10[1])	.04	.03	.09	.18	.19	.22	.16	.38	.32	.15	.19	.27	.21

[1]) These values are the sum of the albuminoid nitrogen and free ammonia, since the latter quantity was not determined directly on this set of samples.

variation in the ratio is apparent, but it should be remarked that the two lowest values for this ratio correspond to the two greatest depths studied, although this may be of no great significance. It will be of interest to make both determinations on samples from greater depths. The variation in the ratio also shows how little justified is the ordi-

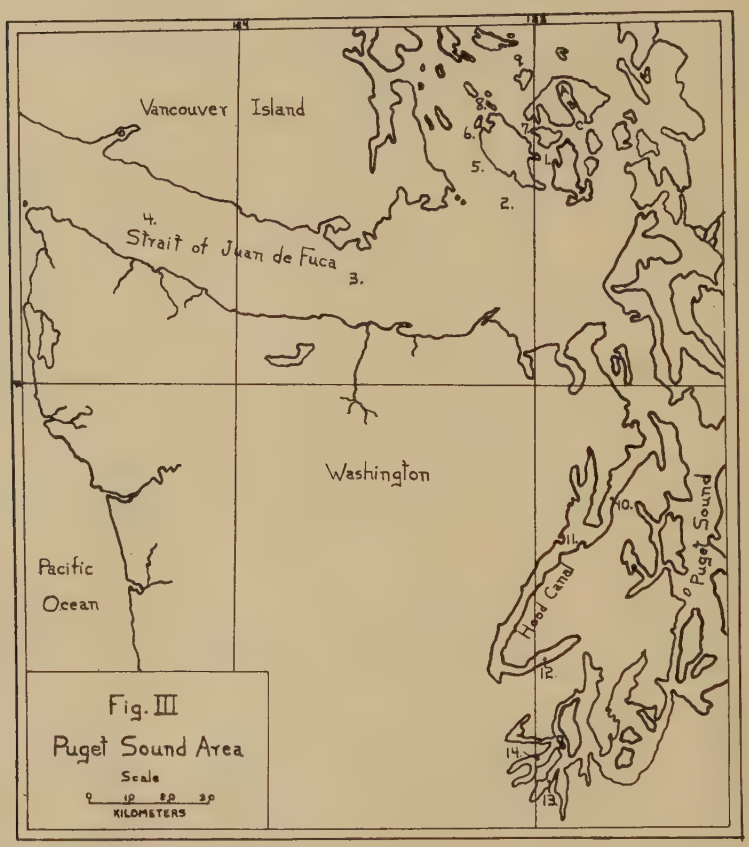

Fig. III. Map of the Puget Sound area, showing the location of the stations. For detail map of the San Juan Islands see Fig. IV.

nary assumption that a constant fraction of the organically bound nitrogen is liberated by distillation with alkaline permanganate.

As Fig. I and II show, the average organic nitrogen content decreases with depth, and in the East Sound area, shows a maximum at five meters. This would indicate that the organic nitrogen is definitely correlated with the intensity of plankton growth.

Only slight variation in the amount of organic nitrogen was found between different localities. The average amount of organic nitrogen

was 0.17 milligram per liter. In East Sound the average was 0.19 milligram over the two-year period, with little variation between the three stations. In view of the luxuriant diatom growth in this region a larger value might have been expected. Hood Canal, which in many respects is similar to East Sound, had an average of 0.14 milligram, while the Strait of Juan de Fuca, which is in direct communication with the Pacific, had an average of 0.15 milligram of organic nitrogen

Fig. IV. Detail map of the San Juan Islands, showing more clearly the location of the stations mentioned in Tables II, III and V.

per liter. The average for Eld and Totten Inlets was the highest found for any region, with 0.25 milligram. This may have been due to the fact that the warm, shallow water, which is only very indirectly in communication with the ocean, is especially favorable for the growth of plankton.

An attempt was made to determine the distribution of the total combined nitrogen, — that is, the sum of the nitrate and organic nitrogen, as the free ammonia and nitrite are too scarce in comparison to influence the result. On account of the unreliability of the absolute values of nitrate only approximate conclusions can be drawn.

The largest average amount of total nitrogen was 0.44 milligram per liter for the Strait of Juan de Fuca. Since the organic nitrogen for this locality was average, the larger value for total nitrogen depended upon the larger amount of nitrate. The results for the other localities were smaller and quite regular: 0.29 milligram for Hood

Canal, 0,31 milligram for Eld and Totten Inlets, and 0.34 milligram of total nitrogen per liter for East Sound.

Although for a given body of water it might be supposed that the total nitrogen content would be more or less constant, considerable fluctuation was apparent for the average amount among the various stations, varying from 0.18 milligram in Hood Canal to 0.59 in the Strait of Juan de Fuca. However, sixty per cent. of the values for individual samples were between 0.30 and 0.40 milligrams of total nitrogen per liter.

The vertical distribution of total nitrogen is dependent upon two opposing quantities; the decrease of organic nitrogen and the increase of nitrate with depth. Although in general the total nitrogen increased with depth, the increase was very irregular due to the different rates of change of the opposing factors.

Summary.

Determinations of the free ammonia, albuminoid nitrogen and organic nitrogen in the waters of the Puget Sound area during the summers of 1931 and 1932 are reported.

The average content of free ammonia was found to be less than 0.02 milligram of ammonia nitrogen per liter.

The albuminoid nitrogen content, averaging about 0.10 milligram per liter in the waters studied, does not show the regular correlation with organic nitrogen that might be expected.

The organic nitrogen content decreases with depth.

No regular variation of total nitrogen with locality was found. This quantity increases with depth, but in an irregular manner.

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The Electrical Conductivity of Sea Water.

By

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I. Introduction.

Karsten (1) first suggested the measurement of the electrical conductivity as a means for ascertaining the concentration of sea water. The work was continued by Tornöe (2) and Knudsen (3). Later Ruppin (4) determined the specific conductance on seven samples of sea water at 0°, 15° and 25° C. In 1918 Thuras (5) and van der Pol (6) measured the specific conductance for a restricted range of chlorinities at 25°, while Rivers-Moore (7), using frequencies as high as 100,000 cycles, showed that the conductance did not vary with the frequency. Since the appearance of the above papers, more exact values for reference standards in conductivity measurements have been made by Parker and Parker (8) and Jones and Bradshaw (9) using potassium chloride solutions. Furthermore the precision of conductivity measurements has been materially advanced by improved design of alternating current bridges as the result of the work of Jones and Josephs (10), Shedlovsky (11) and others.

When the present work was started, the accepted values of specific conductance of sea water were not very accurate, those of Thuras being the most precise. Ruppin's values, while more extensive, were given to only three significant figures, the last of which was in doubt. In view of these facts, it was evident that before any progress could be made in conductivity studies of sea water, it was necessary to make accurate determinations of the specific conductance as a function of the temperature and composition. This is the primary purpose of the present investigation.

Aside from its application to the study of the composition and physical chemistry of the sea, the conductivity has important practical applications. Wenner (12) has adapted it for the determination of the salinity or chlorinity, and the apparatus developed by him has been

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employed successfully by the United States Coast Guard and on the last cruises of the "Carnegie". With proper temperature control, it is probably the most exact method for the indirect estimation of the total salt content of ocean waters.

In planning the present investigation, it was expected that conductivity methods would be fundamental in the study of the composition of sea water. Thus to establish the temperature-chlorinity-conductivity relationships, samples of sea water were utilized which had not been diluted by influx of river waters or in which marked photosynthetic reactions had taken place. Such influx might cause a variation in the conductivity which would differ from that obtained on true ocean water diluted to the same extent with pure water. The experimental work consisted of the determination of the chlorinity and conductivity of samples of true ocean water and such water diluted with conductivity water to an extent which would cover the range of chlorinities ordinarily encountered in nature. The data obtained in this way has been analyzed to establish the deviation of naturally diluted water from the arbitrary standard.

II. Apparatus.

The Thermostat and Thermometers. An oil bath was used to keep the cells at constant temperature. This was regulated to 0.001° by means of an apparatus similar in principle to that described by Beattie and Jacobus (13). The oil bath was placed in a water thermostat maintained at a temperature just below that of the oil by means of a refrigerating coil.

Four Beckman thermometers were used to measure the temperatures. One was set at 0° C. and 5° C.; another at 10° C. and 15° C.; and a third at 20° C. and 25° C. The fourth thermometer was set at 25° C. as a check upon the other. All of the thermometers were set by reference to the ice point at 0° C. and the sodium sulfat transition point at 32.384° C., using a Beckman thermometer calibrated by the United States Bureau of Standards for intercomparison. Temperatures referred to the two points checked to within 0.02°. Since the difference between the temperature coefficients of conductivity of sea water and the standard potassium chloride solution used to calibrate the conductivity cells is very small, this discrepancy in the absolute value of the temperature is immaterial.

The Oscillator. A vacuum tube oscillator was used as a source of alternating potential for the bridge. This was arranged with suitable capacitances and inductances to give a range of frequencies, but all of the actual measurements were made at 1000 cycles at a potential of 0.8 volt.

The Bridge. The Grinnel Jones conductivity bridge, manufactured by the Leeds and Northrup Company, was used. This instrument has been described in considerable detail by Dike (14).

The bridge was calibrated three times during the course of the work, and it was found that the changes in the value of the resistors were

too small to require any correction of the first calibration. To obviate the possibility of such changes, the temperature and humidity of the laboratory were controlled within rather narrow limits.

The Detector. The detector leads from the bridge were connected to a two-stage amplifier tuned to the proper frequency. This arrangement, when used with tuned telephone receivers, permitted the use of extremely small current in the cell.

The Conductivity Cells. Three cells of the Washburn pipet type were used. In the range of concentrations which was measured, these gave resistances which varied from 800 to 8000 ohms. These resistances are well within the range for which polarization errors are negligible. The electrodes were given a moderately heavy coating of platinum black.

III. Experimental Methods.

The Determination of Chlorinity (15). Because of its great precision the Volhard method was used. By weighing the samples and the standard silver nitrate solution, results which checked to one part in ten thousand were obtained. Weighings were made by assuming all weights to be of brass of density 8.4. The density of the air was taken from tables using observed values of the barometric pressure and temperature. Atomic weights of 1932 were used.

The precipitation was carried out in a 150 ml. glass-stoppered Erlenmeyer flask. After weighing the latter, 25 ml. of sea water was then placed in the flask by means of a pipet of large bore for very rapid delivery to avoid the possibility of evaporation losses during transfer. The flask was immediately restoppered and weighed again. By means of the same pipet 25 ml. of the same water was measured in another flask and titrated by Mohr's method to ascertain the approximate amount of silver nitrate necessary for precipitation. A quantity of silver nitrate solution, about 0.1 ml. in excess, was then added to the weighed sample of sea water. The flask was again reweighed, 1 ml. of 6 N nitric acid added, and the contents shaken vigorously for five minutes in order to coagulate the precipitate. The flask was placed in the dark and allowed to stand over night before filtration.

The filtrate and washings, received in a 250 ml. Erlenmeyer flask, were evaporated, without boiling, to a volume of 10 ml. The solution was cooled, three drops of a saturated solution of halide-free ferric alum added, and the solution titrated immediately with 0.05 N potassium thiocyanate solution, using a 10 ml. microburet.

Standardization of Silver Nitrate. The silver nitrate solution was standardized against specially purified sodium chloride by a method approximating the procedure used in the determination of chlorinity.

The choice of sodium chloride as a standard was made because (a) it is relatively easy to purify and dry; (b) it is preferable to potassium chloride because the atomic weight of sodium is accepted to a

greater number of significant figures than is that of potassium; (c) sodium chloride is the principal constituent of sea water.

Merck's Blue Label sodium chloride was purified by a double precipitation with concentrated hydrochloric acid. This purified product was then crystallized three times from conductivity water by evaporating the solution in a platinum dish. The final product was dried for 24 hours at 110° C. and then ignited for the same length of time in a platinum crusible to 700°. A pure whiteproduct was obtained and solutions of it gave negative tests for hydrolysis when treated with phenolphthalein. The samples of sodium chloride were weighed to 0.02 mg.

Standardization of Thiocyanate Solution. The solution was standardized by titrating a weighed sample of the silver nitrate solution. Duplicate results checked to two parts in one thousand and since the silver nitrate titrated in the chlorinity determination seldom amounted to more than 0.200 g., the accuracy of the standardization was ample.

The Determination of Conductivity. The cells were each filled three times with the solution to be measured. The fourth filling was carefully done to avoid trapping of air bubbles against the sides of the cell or the electrodes, and the cell and contents brought to the desired temperature. The latter operation required about forty minutes, but readings were repeated at intervals of five minutes until three consecutive readings showed that temperature equilibrium had been attained. After making the readings and before proceeding further, the ratios between the resistances were calculated in order to ascertain whether or not they agreed with the known values of the cell ratios and to show if results which checked had been obtained. The measurements with the standard solutions were made at five degree intervals, beginning at 25° and ending at 0°. They were repeated at the same intervals beginning at 0°. No differences in the readings were noted which showed that the thermal lag in the cell was negligible.

Calibration of Cells. The cell constants were determined with the 0.1 D potassium chloride solution proposed by Parker (16). The potassium chloride was purified by crystallizing three times from conductivity water. The salt was dried at 105° C. for 24 hours and then ignited in a platinum crucible at 700° C. for an equal period. The product was white and gave no test for hydrolysis with phenolphthalein (17).

IV. Experimental Results.

The Samples. The water used was taken from different depths and various sections of the Pacific and Indian Oceans and the Mediterranean Sea. The samples which had been stored for some time were kept in a very resistant glass and analyses showed that the silicon content of the water had not been affected. The samples of low chlorinity were prepared by diluting ocean water with conductivity

Table I.

Description and Source of the Various Samples Studied.

Number	Depth Metres	Place of Origin		
1	Surface	Strait of Juan de Fuca	47° 20′ N	122° 55′ W
2	200	Haro Strait	48° 30′ N	123° 10′ W
3	Composite 0—1000	Gulf of Alaska		
4	Surface	Puget Sound	47° 34′ N	122° 27′ W
5	2000	Indian Ocean	12° 09′ S	119° 53′ E
6		Indian Ocean (Dilution of Sample No. 5)		
7		Indian Ocean (Dilution of Sample No. 5)		
8		Indian Ocean (Dilution of Sample No. 5)		
9	1900	Gulf of Alaska	57° 43′ N	137° 30′ W
10		Gulf of Alaska (Dilution of Sample No. 9)		
11		Gulf of Alaska (Dilution of Sample No. 9)		
12		Gulf of Alaska (Dilution of Sample No. 9)		
13	2000	Mediterranean Sea	35° 06′ N	17° 24′ E
14		Mediterranean Sea (Dilution of Sample No. 13)		
15		Mediterranean Sea (Dilution of Sample No. 13)		
16		Mediterranean Sea (Dilution of Sample No. 13)		
17		Mediterranean Sea (Dilution of Sample No. 13)		
18	Surface	Mediterranean Sea	31° 36′ N	20° 12′ E
19	800	Pacific Ocean	28° 17′ S	177° 01′ E
20	Surface	Puget Sound	47° 22′ N	123° 07′ W
21	Surface	Gulf of Alaska	57° 55′ N	137° 05′ W

Table II.

Chlorinity and Conductivity of Sea Water.

Chlorinities are in ‰. Conductivities are in reciprocal ohms per cm^3.

The following eight samples were used for the calculation of the Interpolation Formulas.

Sample Number	Cl ‰	25°	20°	15°	10°	5°	0°
5	19.227	.052671	.047549	.042602	.037822	.033258	.028868
6	14.006	.039656	.035776	.032026	.028404	.024945	.021598
7	10.476	.030494	.027499	.024602	.021801	.019118	.016537
8	5.147	.015907	.014330	.012804	.011328	.009929	.008565
9	18.998	.052128	.047058	.042155	.037404	.032898	.028492
10	16.750	.046575	.042044	.037673	.033404	.029348	.025438
11	12.063	.034661	.031263	.027980	.024815	.021766	.018836
12	7.559	.022651	.020414	.018258	.016169	.014163	.012238

The following additional determinations were made at 25°.

No.	Cl ‰	25°	No.	Cl ‰	25°
1	16.753	.046572	16	3.084	.009900
2	17.261	.047830	17	1.476	.004977
3	18.598	.051121	18	21.398	.057901
4	16.240	.045287	19	19.069	.052286
13	21.381	.057855	20	9.086	.026787
14	15.226	.042744	21	17.512	.048455
15	9.075	.026753			

water having a specific conductance smaller than 10^{-6} reciprocal ohms. These diluted samples were selected so as to space the resulting chlorinity values over the entire range. Table I gives a description of the samples.

The experimental data are shown in Table II. Each of the chlorinity values represents the mean of three determinations which checked to within 0.002 $^{0}/_{00}$. The value of the specific conductance is the mean of determinations with the three different cells. The deviations of the individual results were rarely greater than 0.01 per cent.

V. Analysis of Results.

Interpolation Formulas. Using the method of least squares, the data given in Table II have been analyzed and the following interpolation formulas have been derived:

0°C $L = 1.7875\times10^{-3}Cl - 2.9596\times10^{-5}Cl^2 + 1.127\times10^{-6}Cl^3 - 1.902\times10^{-8}Cl^4$

5°C $L = 2.0818\times10^{-3}Cl - 3.6859\times10^{-5}Cl^2 + 1.449\times10^{-6}Cl^3 - 2.520\times10^{-8}Cl^4$

10°C $L = 2.3749\times10^{-3}Cl - 4.1331\times10^{-5}Cl^2 + 1.554\times10^{-6}Cl^3 - 2.643\times10^{-8}Cl^4$

15°C $L = 2.7009\times10^{-3}Cl - 5.1390\times10^{-5}Cl^2 + 2.097\times10^{-6}Cl^3 - 3.829\times10^{-8}Cl^4$

20°C $L = 3.0191\times10^{-3}Cl - 5.6253\times10^{-5}Cl^2 + 2.181\times10^{-6}Cl^3 - 3.804\times10^{-8}Cl^4$

25°C $L = 3.3524\times10^{-3}Cl - 6.2481\times10^{-5}Cl^2 + 2.371\times10^{-6}Cl^3 - 4.049\times10^{-8}Cl^4$

Table III.

Specific Conductance of Sea Water at Various Temperatures and Concentrations.

Chlorinities are in parts per mille. Conductivities are in reciprocal ohms per centimetre cube.

Cl $^{0}/_{00}$	0°	5°	10°	15°	20°	25°
1	.001839	.002134	.002439	.002763	.003091	.003431
2	.003556	.004125	.004714	.005338	.005971	.006628
3	.005187	.006016	.006872	.007778	.008702	.009658
4	.006758	.007845	.008958	.010133	.011337	.012583
5	.008327	.009653	.011019	.012459	.013939	.015471
6	.009878	.011444	.013063	.014758	.016512	.018324
7	.011404	.013203	.015069	.017015	.019035	.021121
8	.012905	.014934	.017042	.019235	.021514	.023868
9	.014388	.016641	.018986	.021423	.023957	.026573
10	.015852	.018329	.020906	.023584	.026367	.029242
11	.017304	.020000	.022804	.025722	.028749	.031879
12	.018741	.021655	.024684	.027841	.031109	.034489
13	.020167	.023297	.026548	.029940	.033447	.037075
14	.021585	.024929	.028397	.032024	.035765	.039638
15	.022993	.026548	.030231	.034090	.038065	.042180
16	.024393	.028156	.032050	.036138	.040345	.044701
17	.025783	.029753	.033855	.038168	.042606	.047201
18	.027162	.031336	.035644	.040176	.044844	.049677
19	.028530	.032903	.037415	.042158	.047058	.052127
20	.029885	.034454	.039167	.044114	.049248	.054551
21	.031227	.035989	.040900	.046044	.051414	.056949
22	.032556	.037508	.042614	.047948	.053556	.059321

These formulas show good agreement with the experimental values in the interval of chlorinities between 5 ‰ and 20 ‰. For values above 20 ‰, the conductivities computed by the formulas are too low, and such concentrations should be interpolated from Table III. The specific conductance of sea water of lower concentration than Cl = 5 ‰ should also be taken from the table.

In table III the specific conductance of ocean water has been calculated for each integral value of the chlorinity from one to twenty-two. These values have been computed by means of the above formulas, except for the chlorinities below 5 ‰ and above 20 ‰, which have been calculated by differences.

Errors. Comparison of the calculated values with the experimental data shown in Table II, considering the chlorinity determinations as correct, shows an average deviation of 0.00001 in the conductances. For a chlorinity of 19 ‰, this represents an error of 0.019 per cent. The error in the entire set of observations is probably considerably less than this amount.

Summary.

The specific conductance of sea water has been measured over the entire range of concentrations found in nature.

The measurements have been made at five-degree intervals from 0° to 25° inclusive.

The data obtained by experiment have been analyzed by the method of least squares, and interpolation formulas for the calculation of intermediate values have been derived for all of the temperatures at which the measurements were made.

Tables have been calculated giving the specific conductance for every integral value of the chlorinity between 1 ‰ and 22 ‰ inclusive at each of the temperatures.

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15. Chlorinity is defined as the total weight of halides, calculated as chlorine, in a kilogram of sea water and is thus expressed as parts per mille.
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17. *Note.* Jones and Bradshaw (Journ. Am. Chem. Soc., 55, p. 1780, 1933, have recently published redeterminations of the specific conductance of potassium chloride solutions at 0°, 18° and 25° C. While their values show substantial differences from those of Parker, it does not seem advisable to recalculate the results of this work at this time. To do so would involve the use of Parker's standards for 5°, 10°, 15° and 20° and the new determinations for 0° and 25° which would undoubtedly lead to confusion. All of Parker's values are, therefore, retained.

Refractivity-Chlorinity-Temperature Relationships of Ocean Waters.

By

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THE purpose of this investigation was to study the relations between the chlorinity of ocean water and the refractive index ($\lambda = 5893$) at various temperatures. Samples of ocean water were used which had not been diluted by the influx of river waters or in which marked photosynthetic reactions had taken place. Waters were collected from the Pacific Ocean, Puget Sound, the Indian Ocean, and the Mediterranean Sea. These waters and the locations at which they were collected have been described by Thomas, Thompson and Utterback (1). The experimental work consisted in the determination of the refractive index for the D line, and the chlorinity of samples of true ocean water and such water diluted with conductivity water to an extent that would cover the range of chlorinities ordinarily found in nature.

The index of refraction was measured by means of a Bausch and Lomb immersion refractometer at five-degree intervals from 0° C. to 25° C. inclusive. The temperature of the samples was held constant to within 0.02 C. in a thermostat. The temperature of the thermostat was controlled by an automatic regulator operating a heating coil. For the lower temperatures, a hand controlled refrigerating coil was used in addition to the heating coil. The thermometers used to measure the temperatures had been calibrated by the United States Bureau of Standards. The chlorinities, which ranged from 1.477 ‰ to 21.381 ‰, were determined by the Volhard method.

Results. Table 1 contains the experimental results obtained for the different samples of ocean water at the various temperatures.

Table 1.

Showing the refractive index of the samples of ocean water at different temperatures.

Cl ‰	Index of Refraction 0° C.	5° C.	10° C.	15° C.	20° C.	25° C.
1.477	1.33453	1.33442	1.33422	1.33388	1.33350	1.33299
3.084	3509	3499	3477	3441	3404	3350
5.147	3584	3570	3547	3514	3470	3421
7.559	3670	3654	3628	3595	3554	3500
9.075	3723	3706	3681	3643	3601	3546
10.476	3774	3754	3729	3692	3647	3595
12.063	3829	3809	3782	3745	3700	3648
14.006	3897	3877	3849	3810	3763	3711
15.226	3941	3918	3888	3847	3803	3750
16.750	3994	3971	3940	3901	3855	3801
18.998	4075	4047	4017	3977	3927	3874
19.227	4082	4056	4025	3985	3935	3881
21.381	4158	4131	4098	4055	4006	3949

The determinations of the refractive index were made by a least three observers on each sample. At least fifteen determinations were made for each sample and in many cases a greater number were made.

The results were analyzed by least squares assuming an equation of the form

$$n_t = n'_t + b \cdot cl \qquad (1)$$

where n_t is the index of refraction of ocean water at t°C., n'_t is the index of refraction of distilled water at the same temperature, b is a coefficient which is a function of the temperature and cl is the chlorinity in promille. (The chlorinity is defined as the total weight of halides, calculated as chlorine, in a kilogram of sea water and is expressed at parts per mille.) The following equations were obtained:

$$\begin{aligned} n_0 &= 1.33402 + 3.54 \cdot 10^{-4}\, cl & n_{15} &= 1.33340 + 3.35 \cdot 10^{-4}\, cl \\ n_5 &= 1.33391 + 3.46 \cdot 10^{-4}\, cl & n_{20} &= 1.33301 + 3.30 \cdot 10^{-4}\, cl \\ n_{10} &= 1.33370 + 3.41 \cdot 10^{-4}\, cl & n_{25} &= 1.33250 + 3.28 \cdot 10^{-4}\, cl \end{aligned} \qquad (2)$$

Table 2, prepared from the above equations, gives the index of refraction for each temperature of integral values of chlorinities from 1 ‰ to 22 ‰ inclusive.

The constants, n'_t, in equations 2 are the values of the index of refraction of pure water for the D line. The values given by different observers for the index of pure water are not in good agreement. The greatest number of determinations have been made at 20°C. and 1.33301 is a mean value. Hall and Payne (2) obtain the value 1.33251 at 25°C., while Baxter, Burgess and Daudt (3) get 1.33248 at the same temperature. Gifford (4) obtains 1.33343 at 15°C., a value probably too great. Other experimenters have determined empirical equations for the rate of change of the index with temperature. The

equation proposed by Osborn (5) results from very precise measurements.

The International Critical Tables (6) give the following values of the index at the temperatures used in these experiments:

Temperature	0°	5°	10°	15°	20°	25° C.
Index	1.3340	1.3339	1.3337	1.3334	1.3330	1.3325

The values af the constants, n'_t, in equations (2) were chosen from a study of the results given by various observers for the index of refraction of pure water for $\lambda = 5893$A.

Vaurabourg (7) has measured the index of refraction, for the D line, of sea waters of different densities. When the chlorinities appropriate to his samples are calculated, a comparison of Vaurabourg's results are available. His values of the index of refraction show a deviation from those given here by 7 units in the fifth decimal for a chlorinity of 2.775 at 0° C. and by more than 1 unit in the fourth decimal for some of the higher chlorinities. These deviations from the results of the present work are fairly great and may be accounted for, to a considerable extent, by a comparison of the instruments used in the experiments. Vaurabourg used two refractometers — a Féry and a Zeiss. The Féry refractometer makes use of a hollow glass prism inside of a water bath. A setting consists

Table 2.

Showing the index of refraction for integral values of chlorinities.

Cl ‰	Index of Refraction 0° C.	5° C.	10° C.	15° C.	20° C.	25° C.
1	1.33437	1.33426	1.33403	1.33374	1.33334	1.33283
2	3473	3460	3438	3407	3367	3316
3	3508	3495	3472	3441	3400	3348
4	3544	3529	3506	3474	3433	3381
5	3579	3564	3541	3508	3466	3414
6	3614	3599	3575	3541	3499	3447
7	3650	3633	3609	3575	3532	3480
8	3685	3668	3643	3608	3565	3512
9	3721	3702	3677	3642	3598	3545
10	3756	3737	3711	3675	3631	3578
11	3791	3772	3745	3709	3664	3611
12	3827	3806	3779	3742	3697	3644
13	3862	3841	3813	3776	3730	3676
14	3898	3875	3847	3809	3763	3709
15	3933	3910	3882	3843	3796	3742
16	3968	3945	3916	3876	3829	3775
17	4004	3979	3950	3910	3862	3808
18	4039	4014	3984	3943	3895	3840
19	4075	4048	4018	3977	3928	3873
20	4110	4083	4052	4010	3961	3906
21	4145	4118	4086	4044	3994	3939
22	4181	4152	4120	4077	4027	3972

in moving as a unit the water bath and hollow prism until coincidence is established between a wire and cross hairs in the eyepiece of the instrument. The displacement is read by means of a scale and vernier. The scale reads the first two decimals of the index and as the vernier is divided into twenty-five parts, it can, at the most, give the index to the fourth decimal. The Zeiss refractometer, used by Vaurabourg for the lower temperatures, is capable of precision in settings of four units in the fifth decimal. This instrument is calibrated by using distilled water. Vaurabourg states but one value of the index of distilled water, 1.33406 at 0°C. This is probably too great. No mention is made of temperature control.

The refractometer used in obtaining the results given in this paper is of the immersion type. While it permits of a precision in settings of one in the fifth decimal in the index, this cannot be claimed as the accuracy of the instrument. When account is taken of scale variations, prism angle and index variations, compensator deviations and variation in the focal length of the objective lens, it is seen that the precision of measurement of the index is less than that indicated by the accuracy in setting the instrument. The makers of the instrument have kept the combination of possible errors to such a value that the accuracy of the instrument is three in the fifth decimal. As a difference of three, in the fifth decimal, between two samples can easily be measured, comparison of the index of one sample of sea water with that of another can be made with considerable precision.

Vaurabourg's experiments were made in order that values of the refractive index would furnish, indirectly, values of the density, and for densities to have an uncertainty of two units in the fourth decimal, it was only necessary to measure the indices to within one half unit in the fourth decimal.

Conclusions. Values of the index of refraction are given for each integral value of chlorinity from one to twenty-two at five-degree temperature intervals from 0°C. to 25°C. inclusive. These values have an accuracy of 0.00003. The results show that a measurement of refractive index will furnish values of the chlorinity. The method is a convenient one for chlorinity determinations on shipboard. The precision of the determinations is being extended by means of an interferometer.

We extend our thanks to Miss Gertrude Fleming and to Mr. Eugene Miller for aid in making the many observations.

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On the Occurrence of two Pelagic Copepods, *Acartia bifilosa* and *Acartia tonsa*, in the Brackish Waters of the Netherlands.

By

H. C. Redeke.

ACCORDING to Ostenfeld (1931) three species of the pelagic genus *Acartia* are more or less common in the plankton of the International Area, viz. *Acartia clausi* Giesbr., *Acartia longiremis* (Lillj.) and *Acartia bifilosa* (Giesbr.)

The first is a temperate oceanic species, present in the whole of the North Sea and the whole of the English Channel.

The second is a true boreal neritic species, rare in the English Channel and the North Sea, but rather common, at times, along the West-coast of Norway, in the Skagerak, Cattegat and the western part of the Baltic, and common around the Faroes.

The third is a brackish water species, known from the Baltic, the North Sea and the British Isles. In the area it is rather common in the whole Baltic (with the exception of the northern half of the Gulf of Bothnia) and the Belt Sea, more scarce in the Belts, the Cattegat and the Skagerak. With the exception of a few occasional records in the North Sea and the English Channel it is absent from the rest of the area investigated. In the Baltic it is present in all seasons, but most abundant in the late summer. (Ostenfeld, l. c. p. 635).

Leaving the two first-named species out of regard, I am of opinion that Ostenfeld's statements as to the distribution of *Acartia bifilosa* in the North Sea area need some amendment. It is quite true that it has been caught very rarely in the open North Sea, but it occurred as a brackish water species very abundantly in the estuarine zones of the North Sea area, especially in the Netherlands: Easter Sheld (Redeke, 1902), Zuiderzee (van Breemen, 1905; van Breemen and Redeke, 1907). Of similar localities it has been recorded from the Jade-Busen (Poppe, 1885, sub nomine *A. intermedia)*, the Norfolk Coast (Gurney, 1904), and inner part of the Firth of Forth (Scott, 1906).

I confine myself intentionally to these few early records, as recent investigations have shown that *A. bifilosa* completely disappeared

many years ago from the Netherland waters and was rather suddenly replaced by a new species, *Acartia tonsa*. This intruder has established itself as a regular plankton form of our brackish waters and is nowadays as numerous as *Acartia bifilosa* was before.

It may be that the same thing has occurred in other parts of the North Sea area, and it is very likely that in later years several authors, as we did, have confused the two species. I think, therefore, that it will be welcomed by all planktologists, if I publish the results of my inquiries as to the occurrence of these copepods in Holland. Perhaps it may cause them to look through their old samples in order to fix the exact time of the appearance of *Acartia tonsa* in European waters.

Acartia bifilosa was described by Giesbrecht (1884, sub nomine *Dias bifilosus)* from the Kieler Föhrde, where as he states, it could be found in rather large quantities in nearly all seasons, but most frequently in spring-time and summer. (For other localities *vide supra).* In the Netherlands *Acartia bifilosa* occurred not only in the estuaries but also in the larger canals and other brackish (mesohaline) inland waters and was, as in the Baltic, most numerous in summer and autumn.

Acartia tonsa was first described by Jacobus D. Dana in his "Conspectus Crustaceorum" (1847—1849). This "Conspectus", however, contains only preliminary and very short diagnoses. Some years afterwards the author gave a fuller description and figures of the species in his "Report on the Crustacea", being Vol. XIII of U. S. Exploring Expedition during the years 1838—1842 under the command of Chas. Wilkes. As only one hundred copies of this report have been printed, and it is therefore rather difficult to procure, I give here *in extenso* the English text of Dana's original description[1]).

> "Front rounded. Cephalothorax obtuse behind, six-jointed, head separate, posterior segments three, and subequal. Anterior antennae many-jointed, straight, as long as the cephalothorax, the tips not in advance of the front, near the base bent at an angle, and from thence straight, apical joint minute; setae mostly short, apical and two or three others nearly as long as one fourth the antenna; posterior antennae slender, one branch three times the longer. Caudal stylets very short, but a little oblong .
>
> Collected in Port Jackson, New South Wales, March, 1840.
>
> Length, one-eighteenth of an inch. Colourless. The front of the head is scarcely at all prominent between the anterior antennae. These antennae at the fourth joint bend directly out, and each falls slightly back of a common straight line. At the bend there is a longish seta, another on the fifth joint from the apex, one a little shorter on the anterior side of the second and a much shorter one on the posterior side of the same joint. The setae of the last

[1]) I owe this description to the courtesy of the Director of the Science Library, London, who sent me a copy.

and the penult joint are nearly equal, that of the posterior antepenult is of the same length or a little longer, but the anterior antepenult, and both on the joint next preceding, are quite short. The third joint from the apex is longer than the fourth or second. The caudal setae are not quite so long as the abdomen. The length of the abdomen little exceeds one-third the cephalothorax. The eyes are situated on a single quadrate spot of pigment, which is rather large."

Both *Acartia bifilosa* and *Acartia tonsa* brought by Steuer (1915) into his new sub-genus *Acanthacartia* belong to the Acartiae rostratae, that is to say, they are provided with a pair of delicate but rather

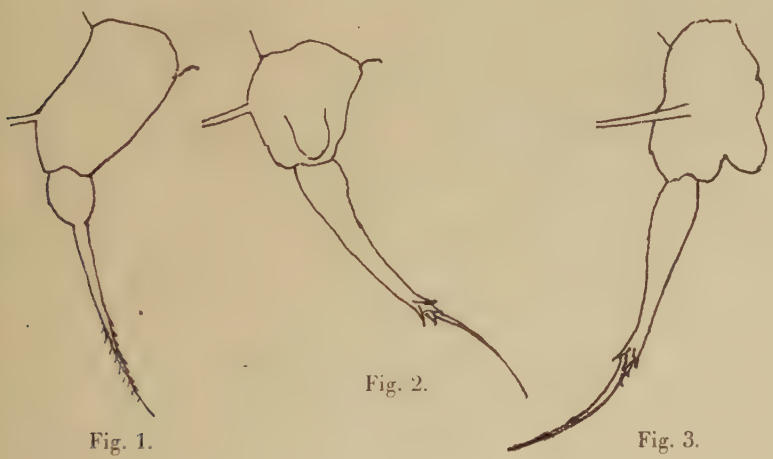

Fig. 1. Fig. 2. Fig. 3.

Fig. 1. — Fifth foot of *Acartia bifilosa*, female.
Fig. 2. — Same of *Acartia tonsa*, female.
Fig. 3. — Same of *Acartia tonsa*, viewed laterally.

conspicuous filaments, which are inserted on the front of the cephalothorax between the first antennae. The contour of the body is as in most Acartiae, torpedoid and shows no characteristic differences. The first two abdominal segments in *bifilosa* have transverse dorsal rows of minute hairs, in *tonsa* there are only a few lateral hairs on these segments. In *bifilosa* the furcal rami are nearly twice as long as wide, in *tonsa* they are subquadrate. The fifth pair of feet in the males differs somewhat in shape and spinulation, but the fifth pair in the females shows very remarkable differences. As the shape of these feet offers the best and easiest characters to distinguish between the two species, I give here figures of both.

It will be seen that the basis in *Acartia bifilosa* is more oblong than in *Acartia tonsa*. The latter has, moreover, a stout distal tubercle,

well visible in lateral view. The exopod in *bifilosa* is straight and slender, with a swollen basis and fine marginal spinules. In *tonsa* the basis of the exopod is hardly enlarged. It has about half way a small number of very conspicuous spinules and ends in a slightly curved and flattened filament.

In later years *Acartia tonsa* has been reported from the west coast of South America between Valparaiso and Callao. (Giesbrecht, 1889). On the Pacific coast of North America Esterly (1905, 1924) found it in the San Diego Region, at La Jolla and in San Francisco Bay. On the east coast of North America *Acartia tonsa* is widely distributed and very common. Wheeler (1901) lists it as one of the commonest copepods at the wharf of the U. S. Fish Commission at Woods Hole. It appeared abundantly also in plankton from Plymouth Harbor (Mass.), but was very scarce in the Gulf Stream, 70 miles south of Martha's Vineyard. Sharpe (1911) reports it from Jamaica Bay (N. Y.) and again from the Woods Hole region. Here, he states, it occurs abundantly in nearly all the tows examined, and even in brackish water ponds. According to Williams (1906) *Acartia tonsa* is abundant in summer in Charlestown Pond, where it is the predominant copepod. He (1907) found it also in summer in Narragansett Bay.

Other records are: near the mouth of the Orinoco (Cleve), coast of Louisiana (Foster), Falkland Islands (Scott), Fundy Bay (Steuer). From the Indian Ocean it has been reported by Cleve and Wolfenden. (cf. Remy, 1927).

Remy (l. c.) was the first to discover *Acartia tonsa* in Europe. He found it on August 8th, 1925, in the brackish water of the canal from Caen to the sea, near Ouistreham. Here it was extremely numerous and by far the most predominant crustacean of the plankton. A few days afterwards it was observed, in much smaller quantities, in the same canal near Bénouville, where the water contained less salt than at the first station.

Finally Klie (1933) found *Acartia tonsa* in small numbers in samples collected in the Weser between Bremen and Bremerhaven (summer 1930) and subsequently in large numbers in the fishery harbour at Wesermünde, October 1931. He was also able to show its presence in collections from the Ringkjöbing Fjord of the year 1921.

After reading Klie's paper I was rather anxious to look for *Acartia tonsa* in our own material, especially in that of former years. Recent samples, collected in 1932 and 1933 in the enclosed Zuiderzee, contained the species in enormous quantities, but not a single specimen of *Acartia bifilosa*. Likewise it was the predominant copepod in the Amstelmeer and other brackish inland waters of Noordholland, and very common in samples from Frisian canals, collected in the years 1928—1930.

Going further back, I found *Acartia tonsa* in samples from the open Zuiderzee (1927), the Haringvliet, Rhine estuary (1926), some Frisian "meres" (1925), the mouth of the Eem, a little river running

into the Zuiderzee (1922), the Alkmaarder Meer and the Noordhollandsch canal (1921), the Zuiderzee and various brackish localities in Noordholland (1920).

Going still further back, it was present in the Zuiderzee, Haringvliet and Nieuwe Maas (1919), Alkmaarder Meer (1918), Frisian canals (1917) and finally in the whole Zuiderzee (August—September, 1916). In nearly all these catches *Acartia tonsa* was very abundant and none of them, as far as I could see, contained even a single specimen of *Acartia bifilosa!*

Unfortunately my material now shows a serious gap. samples from 1913—1915 are lacking. But in a catch from the Zuiderzee, June 1912, only *Acartia bifilosa* was present, and the same was the case with a few older samples from the same locality, collected in May 1907 and May—June 1905.

We may therefore conclude that *Acartia tonsa* made its appearance in the Netherlands between the years 1912 and 1916 and has in the course of a few years completely replaced the old *Acartia bifilosa.* Perhaps it arrived in European waters from the east coast of North America, where it is, as we have seen, extremely numerous, but further investigations are needed to prove this supposition to be right or not. Most probably a renewed study of Atlantic plankton samples, collected in the years before 1916, will throw some light on this question.

Summary.

The planktonic copepod *Acartia (Acanthacartia) tonsa* Dana made its appearance in the Netherlands between the years 1912 and 1916. Here it is nowadays extremely abundant and one of the commonest copepods of our brackish, especially mesohaline, waters.

Acartia (Acanthacartia) bifilosa, (Giesbr.), still very common in the first decade of this century, seems to have completely disappeared from our waters and is replaced by *Acartia tonsa.*

After this article had gone to Press I had an opportunity to study a certain number of plankton samples from the Zuiderzee, collected in the earlier months of the year, viz. February 1920, March 1921, June 1922, June 1927 and March 1933. All these samples contained *Acartia bifilosa!* In those of February and March it was sometimes very abundant and apparently the only species of *Acartia* occurring. The June samples, on the other hand, contained both *A. bifilosa* and *A. tonsa* in considerable quantities.

My statements as to the occurrence of these Copepods in our country therefore need a correction: *A. bifilosa* has by no means disappeared. My material was in so far inadequate, as I had at my disposal merely summer and autumn samples from the years after 1916. Obviously *A. bifilosa* is to be regarded as a species occurring in winter and spring, whereas *A. tonsa* is a true summer and autumn

species. As far as I can see, the first is to be found till about June and then is replaced gradually by the second.

Now the question arises whether perhaps *A. tonsa* has not always been an inhabitant of our brackish waters and especially whether it was present in the summer and autumn plankton of the Zuiderzee before 1912 and has simply been overlooked. Although samples collected in the months August to December from this period were not obtainable and the question therefore cannot be answered definitely, I am still inclined to think that *A. tonsa* has made its appearance in our waters after 1912. For samples from the Zuiderzee of July 1908 and July 1910 contained only *A. bifilosa*, whereas the July catches from 1916 onward contained *A. tonsa* exclusively.

But, as I have said, further investigations on old plankton material are needed to solve the problem. The chief object of this article was to draw the attention of my foreign colleagues to the fact that *A. tonsa* nowadays is one of the commonest Copepods of the Dutch mesohaline waters and to suggest a new examination of their old *Acartia* material.

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An Arrangement of Nets for Capturing Small Oceanic Fishes.

By

A. Fraser-Brunner.

DURING 1927 I undertook a short fishing expedition off the Cornish coast, with a view to obtaining new records of oceanic fishes for the British fauna. It had previously been evident to me that there is a definite inshore migration at night among certain deep-sea forms such as *Spinax* and *Malacocephalus*, and it seemed reasonable to suppose that something similar might occur among bathypelagic species of more active type. It has been shown, especially in the case of Myctophids, that there is a pronounced nocturnal vertical migration, many species being taken at the surface at night which are not found in the upper layers during the day; the reason suggested being that their large, sensitive eyes are unable to withstand strong light, although I am inclined to think that some more fundamental cause, such as the corresponding rise of the plankton, is responsible. The possibility of a horizontal migration into shallower water, however, has not received much attention.

My initial results at fishing for this quarry met with little success. As the enterprise was a private one and funds were not liberal, work had to be done from a hired launch which was unable to carry any great amount of tackle, or to tow a large net on the length of warp (a long-line 300 fthms. long was used) required for my purpose. The greatest difficulty, however, was the inefficiency of the net. In order to capture the small species anticipated, a net of very small mesh had to be used (about $^1/_8$″ between knots), and this did not seem to allow a sufficient draft of water to pass through it. Consequently, as far as I could gather, its principal function was to push in front of it a body of water which effectively prevented anything of interest from entering the net, and the hope of capturing a creature so active as a Myctophid was very slender.

Before proceeding further, therefore, I conducted a few simple experiments with a muslin bag and some coloured particles in a bath of water, and came to the conclusion that what happened was roughly as follows.

The net, being of close mesh, displaced more water than it allowed

to pass through it. The displaced water streamed out over the top of the net and passed backwards along it to fill the space left behind the net as it moved forwards through the water. The important point noted was that the displaced water actually travelled backwards, not merely relative to the net but to the surrounding water, i. e. the speed of the displaced water relative to the net was greater than the speed of the net.

Having obtained this result, the following theory was based upon it.

Since the displaced water is travelling backwards relative to the surrounding water — i. e., the net has created a backward current — it may be expected to counteract and reduce the forward displacement of a net placed behind it. In other words, the current created by the first net should drive directly into the mouth of the second.

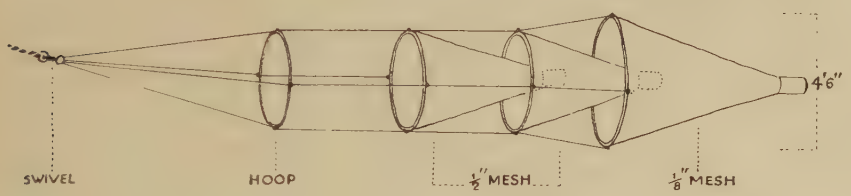

Fig. 1.

There is still a good deal of displaced water from the second net, however, but its speed is greater than that from the first because it is expelled with greater velocity by the first current. The forward displacement of a third net placed behind the second must, therefore, be still further reduced. I was of opinion, and still am, that the speed of the backward current would be the same, relative to the speed of the net, whatever the quantity of water displaced.

Acting upon this hypothesis, two smaller nets with larger mesh (½" between knots) were obtained, and arranged in front of the original net so that the cod-end of each of the first two was in the mouth of the one behind, hoops being used to keep the mouths open, and an additional hoop being placed a few feet in front of the apparatus to prevent twisting. (Fig. 1.)

This contrivance was used subsequently with much greater success. Hauls were made at the surface and at considerable depths some twenty miles out, south-west of the Lizard. Unfortunately, no reliable soundings could be taken, but, although the Admiralty charts show no depth greater than 70 fthms. in that area, at one time 230 fthms. of line was in use; it is realised, however, that the net was probably not sufficiently weighted, and a considerable distance behind the launch. A gratifying collection of young fishes of many species was obtained, including several oceanic forms not hitherto recorded as British. These were mentioned briefly in the "Naturalist" (April 1928), but

as my facilities for correctly identifying the species were limited at that time, several of the names given there are inaccurate. A corrected list of the oceanic species obtained follows.

1. *Bathylagus atlanticus* Günther. 1 specimen.
2. *Yarrella blackfordi* Good & Bean. Many specimens.
3. *Maurolicus muelleri* (Gmelin). Many specimens.
4. *Valenciennellus tripunctulatus* (Esmark). 5 specimens.
5. *Argyropelecus olfersi* (Cuvier). 1 specimen.
6. *Polyipnus spinosus.* Günther. Many specimens.
7. *Astronesthes niger* Richardson. 2 specimens.
8. *Myctophum glaciale* (Reinhardt). 1 specimen.
9. *Lampanyctus elongatus* (Costa). 1 specimen.
10. *Diaphus dofleini* (Zugmayer). Several specimens.
11. *Melamphaes beanii* Günther. 1 specimen.

Most of these have not previously been recorded as British, although *Myctophum glaciale* and possibly some of the others have been obtained by Holt and Byrne and others off the West of Ireland, and *Maurolicus* is known to be of common occurrence on our coast.

Since nearly all this material was taken in the second and (especially) the third nets it is clear that an animal entering the mouth of the first net is swept out again by the displacement, caught in the backward current and driven into one of the nets behind.

This arrangement was later used with equal success by Capt. Hugh Fraser on the west coast of Africa, and the results, including a new genus and two new species, have been recorded by me (Ann. Mag. Nat. Hist., Ser. 10, Vol. VIII, 1931, p. 217).

As far as I am aware, the method had not been used prior to my experiments, and it is now described in the hope that the idea might increase the efficiency of the small-meshed nets commonly used in research work at sea.

Zostera.
Report on the Present Condition of Eel Grass on the Coasts of England, based on a Survey during August to October, 1933.

By

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Introduction.

EEL GRASS, Grass Wrack, or Widgeon Grass *(Zostera)* is a flowering plant found in sand and mud on the sea-shore or in estuaries between high and low water and also in saltwater lagoons. In suitable places it occurs in dense masses with ribbon-like leaves up to 4 ft. long.

There is however a very considerable variation in the size of the plants. The largest forms have leaves 4—5 mm. wide and 30—60 cm. long with 3—7 veins in each leaf. Such forms are usually referred to *Z. marina* L. Frequently, plants have been found in which the leaves are much narrower, smaller and with fewer veins and these are usually called *Z. marina* var. *angustifolia* Hornem.

A similar form to the last, described by Ascherson and Graebner (1) as *Zostera marina* var. *stenophylla*, differs only in the two lateral veins being mid-way between the margin and mid-rib and parallel throughout their length, instead of coalescing with the margin. A still smaller form or species, usually known as *Z. nana* Roth., has very small one-veined leaves only 1 mm. wide.

Coupled with these differences of leaf size and veining is a difference in inflorescence, seed and rhizome. *Z. marina* has brown striated seeds and a thick peduncle shorter than the spathe. *Z. marina* var. *angustifolia* has also brown striated seeds, a slender peduncle thickened upward and as long or longer than the spathe, while *Z. nana* has a slender peduncle as long as or longer than the spathe and smooth white seeds. In addition, this last species is distinguished firstly by having extra-marginal appendages to the spadix and secondly by the anatomical character of the stem [Sauvageau (13)]. The chief difference here lies in the fibre strands which in *Z. marina* are situated

Fig. 1. *Zostera marina* L. The typical plant from Walton-on-the-Naze, Essex.

in the outermost cortex, while in *Z. nana* these are in the inner part of the cortical layer.

In many places on the South and East Coast of England, however, beds of *Zostera* were seen in which various plants with leaves from 1—6 mm. wide were found over a very small area, e. g., at Ryde. Since a great many of the growths had neither flower nor fruit at all, it will be realised that it was not possible on the size of leaf alone to distinguish these three forms satisfactorily. In any case the distinctions based on so variable a character would become artificial. Since the various forms are, however, important from the point of view of this survey, they will be characterised by the width of the leaf and as a general rule such forms may be co-ordinated with the following species:

Leaf 6—4 mm. wide .... *Zostera marina* L.
„ 4—1 mm. wide..... *Zostera marina* L. var. *angustifolia* Hornem.
„ 3—1 mm. wide .... var. *stenophylla* Aschers. and Graeb.
„ 1 mm. wide ..... *Zostera nana* Roth. (other characters distinguish this species).

The inter-relationships and status of these species will be discussed fully in the Report of the Botanical Exchange Club for 1933.

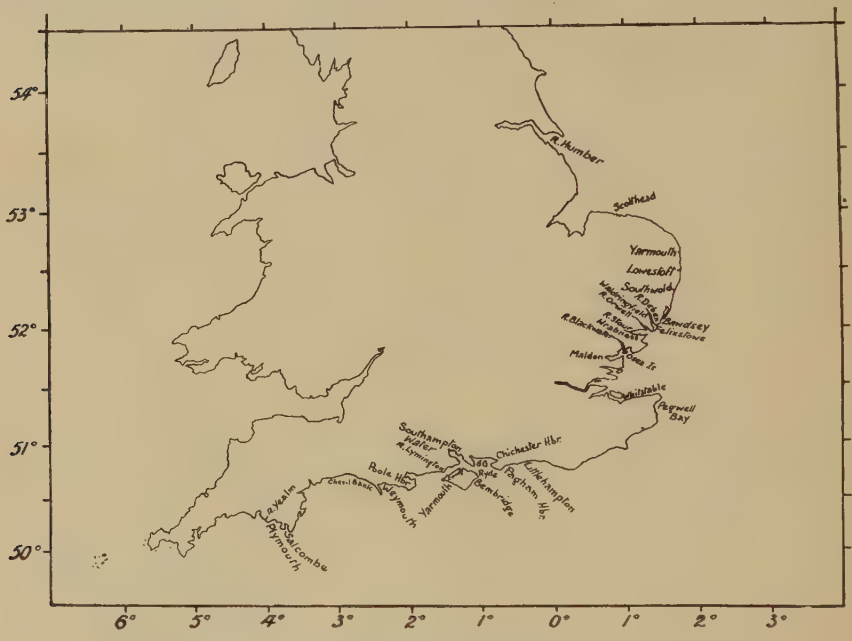
History of the Epidemic.

In October 1932, Huntsman (8) recorded that *Zostera marina* var. *stenophylla* Aschers. and Graebner had diminished all along the Atlantic coasts of North America from Virginia northwards, between the years 1930 and 1932. About the same time (November 1932) Harrison F. Lewis (9) reported a similar denudation of *Zostera* beds along the coast of Nova Scotia, Prince Edward Island and New Brunswick northward to Cape Gaspé. Although this author discusses the possible causes of this disappearance and comes to the conclusion that the two most likely are (1) disease, (2) alteration of one or more of the physico-chemical factors involved in the relationship of the plant and the surrounding medium, he produces no real evidence for either theory.

The next paper on the subject was by Fischer-Piette, Heim and Lami (6), who reported a bacterial disease of *Zostera* around Roscoff, France, and in Holland. They isolated a bacterial organism though no inoculation experiments were made. Two important statements in this paper will be referred to later. The first is that *Zostera nana* is not affected by the disease, and the second is a suggestion that the disease originated in America and was transported by the Atlantic currents, since it appeared a year sooner in America than in Europe. American workers, however, cf. Cottam (3) and Stevens (15), have failed to isolate any causative organism from plants suffering from the epidemic.

The disappearance of *Zostera* in this country was brought to the Ministry's notice in two ways. In October 1932 a fisherman on the

Blackwater reported the death of all the "longweed" and in May, 1933, a report was received from Abbotsbury, Dorset, [C o t t o n (4)] that there was so great a scarcity of eel-grass in the Fleet, (a salt water lagoon, 5 miles long, behind Chesil Beach), that the swans living there had to be fed artificially. Enquiries were accordingly set on foot with the result that it was discovered that, in addition to the two places above-mentioned, *Zostera* had been diminishing for two seasons at Salcombe and in Plymouth Sound and that swans in the Yealm had deserted that estuary for Plymouth, where they were fed by hand.



Map showing the chief places where the growths of *Zostera* have been investigated.

The whole of the Atlantic coast of the United States, Canada, France, England, Holland were thus reported to have been affected in 1932.

This year (1933) additional reports showed that the epidemic had reached Denmark [B l e g v a d (2)] and Sweden [M o l a n d e r (10)], especially in the Bohuslän skerries, along the coasts of the Kattegat and off Frederikshavn. Here the disease is apparently local as *Zostera* is unaffected in the Sound near Elsinore, at Svendborg, Faaborg and Mommark.[1])

In the meantime correspondents in America state that, though new growths have appeared in the affected areas, the plant is still scarce and it is dying in new places further north. The young growths which

[1]) F. C. E. B ø r g e s e n *in litteris.*

were produced in 1932 died in the winter and there is nothing to indicate that the 1933 growths will not share a similar fate.[1])

In other places in Europe also, after a large decrease in 1932, *Zostera* appeared to be again on the increase. So far there has been no report that the *Zostera* beds have been affected along the German and Norwegian coasts, along the Mediterranean coasts of France or the Pacific.

The importance of this plant to the productivity of the inshore fisheries, especially those of the countries around the Baltic, has been

Fig. 2. *Zostera nana* Roth. The typical plant from Pagham, Sussex

emphasised by Petersen (12) and Blegvad (2). The dried material is also of considerable commercial value, as it is used in packing, upholstering and sound insulation. In addition the plant is an important food for Brant geese, swans and other wild fowl and where it has disappeared the birds either starve or migrate elsewhere, [Lewis (9), Cotton (4) etc.]. It should be noted, however, that in places where other flowering plants, such as *Ruppia spiralis* and *Zannichellia palustris* exist, the birds feed on these.

In order to discover the situation in this country a full enquiry has been made in co-operation with Mr. A. D. Cotton, of the Royal Botanic Gardens, Kew. A survey of a large part of the English Coast between Yarmouth and Weymouth has been made by the author and

[1]) H. F. Lewis *in litteris.*

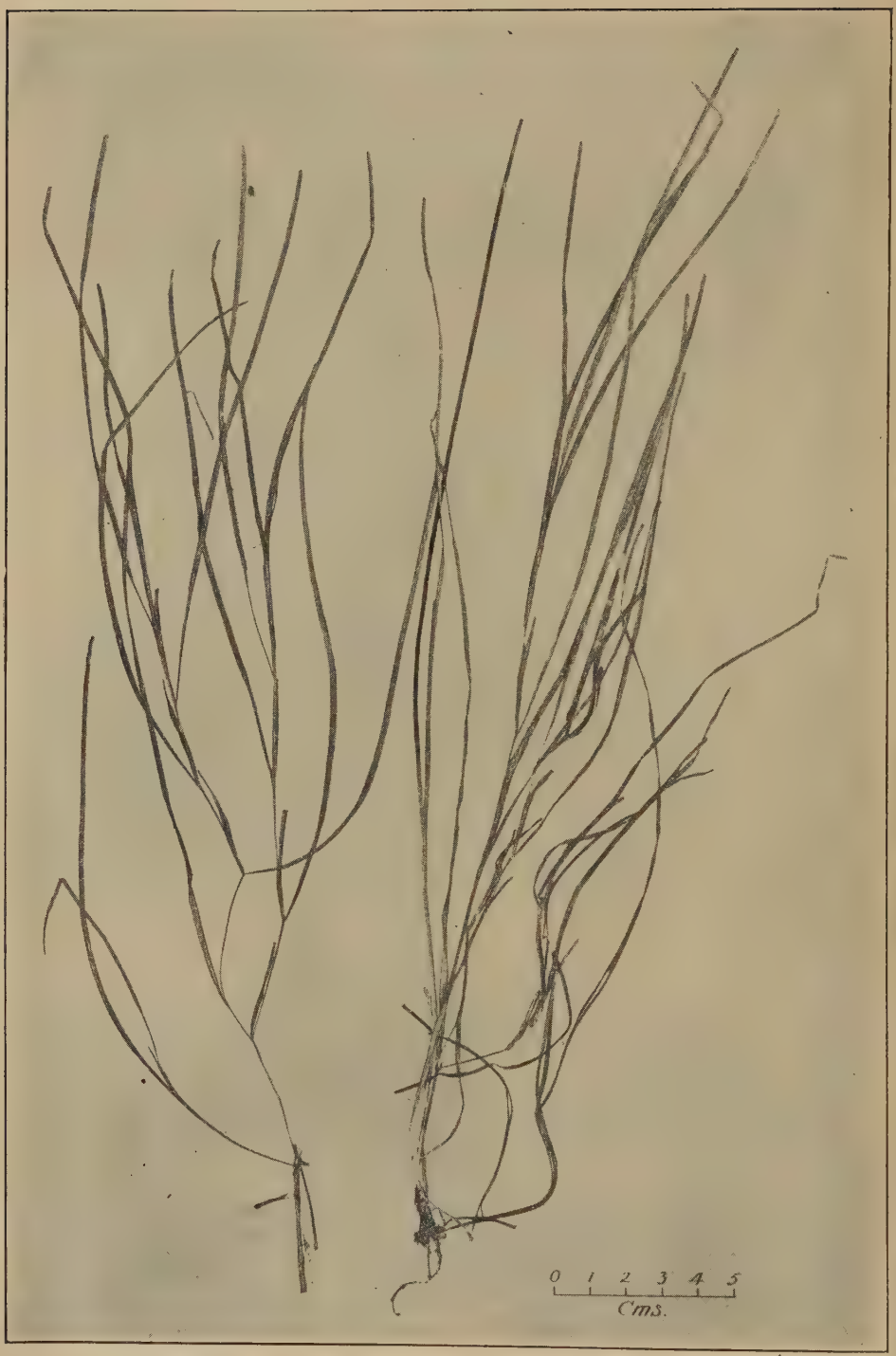


Fig. 3. *Zostera marina* var. *angustifolia* from Chichester Harbour. This is now the prevailing form in most places on the English coast.

information has been obtained from a great many people, whose kind help is hereby gratefully acknowledged.

Distribution of Zostera in England.

Evidence of the distribution of *Zostera* in England is taken from the various County Floras and from the Comital Flora of the British Isles, by D r u c e. (5). Apparently *Zostera* was, or is, abundant in the north-eastern estuaries as far south as the Tees. Although it is not recorded for North and East Yorkshire, it grows in the Humber. From here southwards to the Thames it is found in most estuaries and salt lagoons. In the Thames itself there are records for Southend and Sheerness, but not further up the estuary. It is recorded as abundant in similar places along the whole of the South coast. On the West coasts it is comparatively rare, there being no records for North Devon, the Bristol Channel, Cardigan, Carmarthen and Westmorland. In most places in the West it is thinly scattered.

Z. marina var. *angustifolia* is recorded for most places where the type is found, var. *stenophylla* for Bosham, Sussex, and it occurs elsewhere, and *Z. nana* apparently covers the same area as *Z. marina* though it is more sparsely distributed.

Details of Places Particularly Examined.

Norfolk and Suffolk.

Zostera marina and *Z. nana* are still abundant at Scolt Head[1]) but none could be found at Wells, where it was formerly abundant. Twenty or twenty-five years ago the plant was very plentiful toward the lower end of Breydon Water near Yarmouth, but this year there were only a few patches where before there were continuous beds. What plants there were, were almost entirely those with leaves 3 mm. wide. It appeared to be healthy and it was flowering well. It is said to have been disappearing from here for many years, but more particularly since the War. This estuary is of a bottle-neck type and receives all the drainage water from the Broads and consequently it is rapidly silting up with foul, organic mud. This mud is covered with sea-lettuce *(Ulva)*. It is this silting up that, not without reason, is blamed locally for the disappearance of *Zostera*.

There are records in the Suffolk Flora (7) for Lowestoft, Kessingland, Southwold and Dunwich, but there is no evidence that the plant ever grew in these places and the records probably refer to pieces washed up on the shore.

In the estuary of the Deben in 1917 there were large and almost continuous beds of *Zostera* from Bawdsey Ferry up to Woodbridge made up chiefly of plants with leaves up to 6 mm. wide. In September 1933, there was still a great deal between Waldringfield and Bawdsey with plenty of flower and fruit. This was particularly common in the pools in the depressions of the mud left by the receding tide.

[1]) H. G o d w i n *in litteris.*

None of the plants, however, had leaves wider than 4 mm. and most of it had leaves between 3 and 2 mm. wide. Here the local report is that the wide-leaved form disappeared immediately after the War (1920).

In the neighbouring estuary of the Orwell very little could be found. None could be seen at Felixstowe and Walton where it is recorded in the Flora of Suffolk (7). Higher up at Levringham Creek there was a certain amount of the very smallest form (leaf 1 mm.) and this was not flowering at all. I am informed that ten years ago it was like a hayfield in this particular spot. The Orwell is another estuary which has become filled with foul mud and covered with a dense growth of *Ulva*. Here again local opinion blames sewage and oil. There seems to be no doubt that the large-leaved form used to occur here though now only the small one could be found.

Essex.

By contrast, in the estuary of the Stour, *Zostera* was found to be generally common from just below Manningtree to Wrabness which was the lowest point examined. No information could be obtained of its former distribution. At Manningtree only narrow-leaved plants were seen and these were not flowering, but at Wrabness there were large quantities of a variety of forms with leaves from 4 to 1 mm. and these were flowering and fruiting well. Plants with broad leaves could not be found. *Spartina Townsendii* has recently been planted and has colonised this estuary to a small extent, and it will be interesting to see whether this grass will produce the changes it has on the South Coast.

On the Blackwater, as already mentioned, a large quantity of the plant was reported to have died in 1932 and we were conducted over the ground by the fisherman who had observed it. This September, however, the plant appeared to be healthy with plenty of flower and fruit and it was re-colonising the ground which was denuded the previous year. It was noticed that, though all the varieties were present, the type with leaves over 5 mm. wide was comparatively rare. The fisherman informed us that there was much more this year than last. There is no *Spartina Townsendii* in this estuary.

At Walton-on-the-Naze *Zostera* grows in an inland salt lagoon (salinity 39 per mille) which is used as a boating lake. The proprietors drain off the water annually in April in order to keep down the *Zostera* which is a hindrance to boating. So little had grown last autumn that they found it unnecessary to drain the water in the spring of 1933. In September there was again a considerable amount of the plant, including much in flower and fruit. It is significant that in this sheltered lagoon the plant was all the form with the broadest leaves.

Kent.

There are records for the plant at Sheerness, Faversham, Whitstable, Pegwell Bay and lagoons at Reculver. All these places were visited,

except the first. At none could any *Zostera* be seen nor was there any local information except at Whitstable, where I was informed that the plant used to grow in a depression in the sea-bed known as Grassy Sand because of the *Zostera* there. This depression has now filled in and the plant has disappeared.

Sussex.

All four forms of *Zostera* mentioned on page 51 are recorded for this country; three of them from most of the estuaries along the coast. The Cuckmere and estuaries east thereof were not visited. No *Zostera* was found at Littlehampton, but large beds of the plant were seen in Pagham and Chichester Harbours, though, according to local information, these are not so extensive as formerly. The beds were very local. For instance, there was apparently none on the eastern side of Pagham Harbour near Pagham, but it was plentiful and very varied on the western side. Similarly in Chichester Harbour it was abundant at the south end of Thorney Island and at West Wittering, but none could be seen in Emsworth Channel, or in the neighbourhood of Bosham. In all the Sussex stations, as in Hampshire and Dorset, the estuaries have been considerably altered by the advent of *Spartina Townsendii*.

Hampshire.

Zostera used to be abundant in all the estuaries of the county. The most important localities were Southampton Water and the Isle of Wight. The plant was also common in parts of Hayling Island. There is no record for Christchurch Harbour though it has been seen on the shore at Bournemouth, doubtless washed in from Poole Harbour or the Isle of Wight.

In Southampton Water *Zostera* was formerly very large and abundant from Southampton eastward and up the Hamble River to Bursledon; along the opposite side from Eling south-eastwards and up the Beaulieu and Lymington Rivers. *Zostera marina* var. *angustifolia* and *Z. nana* were also recorded. Now there are only very small isolated patches of the type with leaves 5 mm. wide together with larger beds of plants with leaves between 3 and 1 mm. at Bursledon and Netly. A plant that can undoubtedly be referred to as *Z. nana* was common at Millbrook in 1926. A large area of the estuary is now occupied by *Spartina Townsendii* and here again the foreshore is covered with *Ulva* and *Enteromorpha*. There is no *Zostera* in Lymington River. As at other places, *Zostera* was obviously disappearing eight or more years ago. According to a local fisherman the mud was gradually washed away from between the roots and then large patches were rooted up during the winter storms by wave action.

In the Isle of Wight, *Zostera* is reported as abundant along the north side of the Island from Bembridge to Yarmouth. At Yarmouth the type with leaf 6 to 3 mm. wide was said to have disappeared about seven years ago. A certain amount of the plant, with leaves 2 mm. wide, was seen on the thick, foul mud between the pier and the toll

bridge, but there was none at all up the estuary of the Yar where it was formerly abundant.

At Newtown, five miles west of Yarmouth, there was a good growth of a narrow-leaved form (leaves 1 to 2 mm.) with only a very little flower and fruit on it. This extended for about a mile up the muddy creek.

At Cowes and in the Medina it has apparently disappeared altogether.

At Ryde and Bembridge near the north-east corner of the island there is a plentiful growth of plants, with leaves varying from 6 to 1 mm., as in the Blackwater (Essex), but here it grows on the open sea-shore at about mid-tide zone. The substratum was sandy and moderately firm. In St. Helen's Harbour, adjacent to Bembridge, only the narrow-leaved form was found on the thick, black mud. The distribution of *Zostera* in the Isle of Wight certainly suggests that the plant is to a large extent dependent on the nature of the substratum and hence on the currents which cause or remove the deposits.

Dorset.

Two places in Dorset where *Zostera* was fairly abundant were examined, namely Poole Harbour and the Fleet, near Abbotsbury. In the former locality patches of all varieties could be found, especially on the western shores, but there was by no means as much as formerly.

At Abbotsbury *Zostera* occurs in a long, land-locked lagoon behind Chesil Beach. The amount of sea-water flowing into this lagoon is determined by the wind rather than the tide. An east wind brings the sea-water up the narrow opening at the eastern end and during storms much water comes through the shingle bank. The salinity of this water at the landward end was 27 parts per 1,000 whereas 5 miles down to the opening it was 53, doubtless due to the excessive evaporation during this hot season.

Death of the *Zostera* in the autumn of 1932 had been reported but when the place was visited in 1933 there was a fair amount of the narrow-leaved form with leaves 2 to 3 mm. wide. Places where the typical broad-leaved form had grown were bare mud, but dead leaves were found amongst the debris on the shore. Evidently the narrow-leaved form which bore plenty of flower and fruit has increased considerably since the mortality of the previous autumn. No sign of disease could be detected in these plants.

The water was full of plants of various kinds including *Ruppia spiralis*, *Lamprothamnium papulosum*, free floating masses of certain seaweeds such as *Chaetomorpha* sp. *Polysiphonia* spp., *Ulva lactuca* and *Cladophora* sp. The depth varied from 1—3 feet but the bottom consisted of a very fine black mud.

Present Distribution Elsewhere in Britain.

Devon. From Dr. E. J. Allen and Mr. D. P. Wilson.

In Plymouth Sound, the Yealm and at Salcombe, *Zostera* was wiped out during 1932 except for a few stray plants, but it already

shows signs of new growth. Among this new growth is a considerable quantity of *Z. marina* var. *angustifolia*.

The Humber.

A survey made by Messrs. G. Philip, J. B. Ferry and R. Maslin [1]) in 1933 shows that *Zostera marina* var. *angustifolia* grows in the sandy mud for several miles inside Spurn Point. The occurrence and quantity of the plant is correlated with the consistency of the mud confirming what has been already indicated in my observations on the south coast (see pp. 57—58).

Northumberland. Dr. H. O. Bull and Mr. B. Storrow.

There appears to be no decrease in the quantity of *Zostera* in the three or four localities where it has always occurred, but almost all this material is *Zostera marina* var. *angustifolia*. Some destruction both of this plant and of the fauna was caused in the Blyth estuary by serious pollution of oil from a ship that was being broken up, but here again the plant is gradually recovering and extending its area.

Wales. Mr. H. A. Hyde.

Although still uncommon, *Zostera marina* var. *angustifolia* is apparently slightly extending its area on the southern coasts of Wales.

Scotland. Mr. J. Berry.

Gradual disappearance of *Zostera* has been taking place in the Tay for many years. There is very little information from other estuaries, but what has come to hand indicates that there is very little decrease in these areas.

Ireland.

Disappearance of large quantities of *Zostera* was observed in 1931 and 1932 near Cork [2]). In Strangford Lough near Belfast the situation appears to be similar to that in so many places in England. There has been a gradual decrease for many years especially in the upper parts of the estuary; there was a more marked disappearance than usual in 1931 and 1932 and now there is an increase of the narrower leaved forms of the plant. [3])

Summary of the Present Distribution.

From the information given above, the following conclusions may be drawn as to the condition of eel-grass *(Zostera)* in this country.

(1) *Zostera* has been dying out in a great many places round the British coasts for many years. The general opinion seems to be that it started "since the War", which means at least 8 to 10 years ago. In no place could a definite statement be obtained that the plant was as abundant as formerly, though an increase is indicated in exceptional places. In any case diminution of our *Zostera* beds was taking place several years before the "epidemic" was recorded in America and France. Three places were visited where the decrease

[1]) *In litteris.*
[2]) Mr. L. P. W. Renouf and Mr. G. Somerville.
[3]) Mr. G. Steven.

was first recorded in 1932 and in these places the plant appeared to be recovering and healthy. The same course of events is apparently happening near Plymouth where a decrease was noted in 1931 and 1932.

(2) Denudation of the *Zostera* beds varies considerably from place to place. Apparently the plant has totally disappeared from Southampton Water, Lymington River and from the main Thames Estuary (Sheerness, Whitstable, etc.). At other places (Breydon Water, the Orwell and Poole Harbour) the beds are diminishing rapidly but isolated plants or patches may still be seen.

(3) In a great many places only the broad-leaved type appears to have become rare and the area formerly occupied by this plant is being re-colonised by narrow-leaved forms. This is very obvious at Abbotsbury, Freshwater and in the Deben and the Humber. On the other hand, there is an abundant growth of all forms at Ryde, in the Blackwater, the Stour and in many of the Scottish estuaries.

(4) It is not possible to state the cause of the diminution of the plant. In some places, e. g., Southampton Water, special circumstances apparently led to its destruction, but in most cases there seems to be very little in common as regards both physico-chemical and biological factors which could account generally for its disappearance. To the writer the change in the nature and constitution of the substratum seems to be a very likely cause. Many circumstances also suggest a disease caused by a living organism, but neither this nor the change in the substratum rests at the moment on anything but reasonable conjecture.

Discussion on the Cause and Effect of the Disappearance of Zostera.

Periods of Decrease.

In all the work so far published on this subject, although many factors are discussed, no experimental evidence as to the true causes of the disappearance of *Zostera* can be produced. I find myself in the same position.

In England, two definite periods of decrease in *Zostera* can be distinguished; one immediately after the War, that is between 8 and 12 years ago or perhaps even longer, and another at the same time as the epidemic in France and America, namely in 1931 and 1932.

The depletion of the beds, 8 or more years ago, seems to have been most serious in Southampton Water, where no *Zostera* can now be found. The largest-leaved form seems generally to have suffered most, as in the Deben, on the western side of the Isle of Wight and in Chichester Harbour. On the eastern side of the Isle of Wight, and doubtless in many other places, there seems to have been some decrease in area though this is not very evident. Whether the narrow-leaved forms now to be found in all the above places grew after the broad-leaved forms disappeared, or whether a disease or a change of condition affected only the broad-leaved form, one is not in a

position to state, nor can one say whether, at such places as Ryde, there has been a continuous decrease since 1920 or whether there has been a decrease followed by an increase. There is evidence also that there has been a large decrease in *Zostera* since the War in the Tay in Scotland and in Strangford Lough, Belfast. Another point that it is impossible to ascertain is whether this decrease of about 8 years ago was sudden or gradual. Reliable evidence from the Tay and Breydon Water seems to show that it was gradual but very noticeable.

There was undoubtedly a sudden death of *Zostera* in some places in 1932. It was noticed particularly in the Blackwater, in the Yealm, at Abbotsbury and at Walton-on-the-Naze. In 1933 apparently the plant recovered late in the season. In the Blackwater all the varied forms again grew, at Walton the large-leaved form re-appeared, while at Abbotsbury the broad-leaved form died out, and only the narrow-leaved form could be seen in 1933.

Variation in Susceptibility.

It is apparent from this survey that certain forms of the plant are more liable to die out than are others. Particularly is this evident with regard to the type *Zostera marina* which has leaves up to 8 mm. broad. In many places this form has disappeared altogether. In others, however, it is found almost pure (Walton-on-the-Naze) or mixed with the narrower-leaved forms (Poole Harbour). Fischer-Piette, Heim and Lami (6) state that *Zostera nana* is not affected by disease. Circumstantial evidence would appear to confirm this as there is still plenty of this species to be found. The question then arises as to whether it can be stated that the narrow-leaved forms now dominant on our *Zostera* beds and referred to as *Zostera marina* var. *angustifolia* are also immune from disease. No evidence could be obtained as to whether this last-mentioned plant was common in the places where now no *Zostera* is to be found (Southampton Water), whether in other places it has survived an epidemic, whether it has re-colonised the mud left bare by *Z. marina* or whether it is a form induced by a change in conditions.

All these considerations bring up the further question as to the taxonomic relationship of the various forms and species. Two species *Z. marina* and *Z. nana* differing in several important characters in rhizome, inflorescence and size of leaf (see Setchell (14)), occur together on many of the *Zostera* beds in this country. The prevalent forms of the plant, however, are those referred to as *Z. marina* var. *angustifolia*. These occupy, in size of leaf and general appearance, an intermediate position between the species mentioned above and, undoubtedly, many of the extreme small forms have been wrongly referred to *Z. nana*. It has been suggested that this narrow-leaved variety of *Z. marina* may be a hybrid and the various forms may have arisen as the result of segregation. So far I have found no evidence of any *Z. nana* characters, save the unsatisfactory one of the size of the leaf, in any of the *Z. marina* var. *angustifolia* material, nor

is the occurrence of the narrow-leaved forms in places where *Z. nana* has not been found (e. g., North America, Isle of Man [1]) in keeping with the hybrid theory. Whether there are two plastic species with forms or varieties, immune or susceptible, whether there are even more species, or whether there are two species which hybridise and afterward segregate, only cultivation and breeding experiments can decide, and since these have not been done, it is useless discussing the point further.

Causes of Disappearance.

For a discussion of causes I take Lewis's paper (9) as a basis and add what I can to his conclusions. His list of conceivable causes is:

1. Winter killing due to unusual ice conditions.
2. Too high temperature in summer.
3. Increase in the salinity of seawater, to a point at which the plant could not live.
4. Destruction by waves and storms.
5. Consumption by ducks and geese.
6. Destruction by competing plants.
7. Excessive commercial harvesting.
8. Destruction by oil pollution.
9. Disease caused by a bacterium, fungus or other living organism.
10. Alteration of one or more of the physico-chemical factors involved in the relationship between the plant and the surrounding water with its solutes. (Also one may add the substratum in which the plant grows.)

It is not inconceivable that the cause of the disappearance may be due to different factors in different places. Whilst the coincident deaths during 1930—32 of so much of the plant all over the world suggest a common cause or causes such as disease, the fact that this survey has revealed that *Zostera* was diminishing for some time previously, would, on the other hand, support the idea that disease caused by a living organism is not the only factor to be considered.

Killing by low or high temperature on an extensive scale may be dismissed, as weather conditions in this country are too temperate to affect plants which can survive the more extreme conditions of Canada.

On the other hand it has been suggested by Setchell [2]) that the season at which the temperature rises above a certain point and the rapidity of its rise may be a causative factor. If, for instance, there was a long period in the spring with temperatures below the critical point of vegetative development (10° C), followed by a rapid rise up to a point above the optimum (15° C) it may have prevented the normal development of the plant. This is a possibility, but the temperature records available do not suggest that, in 1932 at least, there was such a sudden rise. Nor does it seem that the sudden rise of temperature in spring would account for the noticeable death of fully developed plants in September, as recorded in several places.

[1]) Miss M. W. Park *in litteris.*
[2]) *In litteris.*

The facts are also against a sufficiently large change in salinity being responsible, as the range in which *Zostera* can flourish is far greater than any change ever recorded for the sea. At Abbotsbury, for instance, the salinity was found to be 53, on the Deben 37 and at Walton 39. Ostenfeld (11) gives normal range of variation as from 1 to 3 % salt and it is apparently the lower concentration rather than the higher, which is the limiting factor [Blegvad (2)]. Disappearance of *Zostera* high up certain estuaries may sometimes be due therefore to increased dilution by fresh water.

Similarly, destruction by waves may be ruled out, as in many cases denudation of *Zostera* beds has taken place in inland lagoons. Again geese and swans are known not to have fed very extensively at certain places where the plant has disappeared. Very little commercial harvesting is carried on in this country.

Oil Pollution.

It has been suggested that oil may kill the *Zostera* in a variety of ways: (a) by rendering the pollen and seeds infertile; this is very improbable as the plants are always submerged in some of the lagoons where it has died. Also, pollination takes place under water: (b) by a film of oil settling on the plant at low tides; this is conceivable, but here again it does not account for death in lagoons, nor survival in places where oil pollution is serious, e. g., Ryde: (c) by settling in the mud and in some ways upsetting the biological balance between the plant and its substratum. This again is conceivable, especially as regards certain fractions from oil fuel, notably the asphalts, which occur up to 15 %, but it cannot happen where there is no oil pollution.

Disease Caused by Living Organisms.

That the death of *Zostera* is due to a bacterial disease is the opinion of Fischer-Piette, Heim and Lami (6), who announce they have discovered the causative organism. Whatever the cause of the disease, facts in this country are not in agreement with their theory of its American origin. Since *Zostera* was clearly diminishing in this country more than ten years ago, that decrease could not be due to a disease brought across by the Atlantic currents from America about 1930. Either there have been two separate epidemics or the disappearance has been more or less continuous, with the usual variations to be expected with natural phenomena. During this survey no definite evidence of diseased conditions of *Zostera* beds could be seen. It should be pointed out that certain leaves appeared to be dying, but as diseased leaves and those dying at the end of the season from other causes are very much alike in appearance, it is impossible to decide whether the cause of death is normal or otherwise.

Changes in Physico-Chemical Factors.

This covers a multitude of circumstances. Of the possible factors, probably the most important from the point of view of a flowering

plant is the nature of the substratum. This is more likely to change to the disadvantage of the plant living in water than are the composition of the sea-water, the temperature or the light. It is a generally accepted fact that in all estuaries and on the seashore, mud and silt are being continuously deposited or removed as external circumstances determine. With the lapse of time the deposits in our estuaries have become more and more organic and the possiblility of the organic matter in the mud being too great for the healthy growth of *Zostera* seems to be a real one.

A study of the ecology of *Zostera* was made in Denmark by Ostenfeld (11) by which the following facts as to the occurrence of the plant are made clear:

(1) It does not occur on gravel or sand which is being continually shifted by wave action or strong currents.
(2) It will not grow in water with a lower light intensity than that in which a white disc can be seen from the surface. Between tide marks this low intensity is rarely reached.
(3) It will not grow in water of a salinity of much less than 1 % salt, though it occurs in waters with salinity considerably greater than normal sea-water.
(4) Ostenfeld distinguishes two types of plant: a type growing on firm sand with leaves 4—5 mm. wide and a more robust type growing on mud with leaves 5—8 mm. wide.

This author's first three findings explain the general distribution of *Zostera* in this country; its absence from the West, its disappearance from certain estuaries because of the change in the currents and wave action and its confinement to the lower parts of estuaries. The observation that the plants are smaller in sand than in mud does not however fit in with the distribution which I have observed. Generally speaking, the largest patches were found in firm, sandy mud or in streams where the water ran off the mud at low tide, while the smallest plants were found in the very soft black mud. The wide range of variation at Ryde and in the Blackwater also shows that there is no very definite division. Undoubtedly *Zostera* was not seen during this survey in the firm, clean sand such as Ostenfeld describes. Ostenfeld, probably, did not investigate any foul deposits in Denmark such as those in the Thames, Orwell or Southampton Water. It is in such foul places that *Zostera*, if present at all, is smallest.

It seems, therefore, that the amount and nature of the organic matter in the substratum may easily be a limiting factor in many cases. The optimum condition is seen in clean mud, such as found in Denmark or at Walton-on-the-Naze. As the mud becomes fouler the large-leaved plant dies away, and either the small-leaved plant replaces it, or there is a degeneration from one to the other. Many facts fit in with this hypothesis; the alteration of the substratum by oil deposits and the consequent disappearance of the plant, its

disappearance in polluted estuaries, such as the Orwell, together with its persistence in cleaner estuaries near by (the Stour and Blackwater). Possibly the disappearance in land-locked lagoons such as the Fleet, Abbotsbury, may similarly be due to dead plants which contribute largely to the foul mud in this locality.

I am aware that there is no experimental evidence to support this suggestion nor do I think it is the only factor concerned. It seems however to be in a great many cases a reasonable hypothesis and it is put forward as an opening for further investigation.

Finally, marked fluctuations in the quantity of certain plants are well known and have been observed in the English Lakes by Pearsall [1]) and although the scarcity of eel grass may at the present moment be serious, both experience and observation would indicate that in many places there is every hope that it will again return in its former abundance.

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[1]) W. H. Pearsall *in litteris.*

The Age and Growth of Salmon Caught in the Polish Baltic in the Years 1931—1933.

By

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THE RESULTS of the examination of salmon caught with drift-nets and lines in the Polish Baltic in 1929 were published in Vol. VII of the "Journal du Conseil" (1). In accordance with the decisions of March 24th and 26th 1931 of the Salmon and Trout Committee of the International Council, further study of the growth of particular types of salmon was included in the year's programme of investigations. We have, therefore, carried out a further analysis of the composition of the stock with regard to the age and growth-rate of salmon netted in 1931, 1932 and 1933, and caught by lines in 1933. The material collected by the Marine Station for purposes of analysis consisted of overall body-length measurements and scales of 364 drift-net salmon, 67 line-caught and 100 small "mielnica" salmon. In working on this material, as in our former analysis, we employed the Edinger (Leitz) projectional apparatus followed by the E. Lea and K. Dahl method of back-calculation of growth.

Measurements of salmon catches.

According to the data of the Sea Fishery Board for Poland there were caught in the Polish Baltic between Jan. 1st 1931 and Sept. 1st 1933:

1) 201,180 Kg. large salmon, in spring with drift-nets and in winter with lines.
2) 50,360 Kg. small salmon, so called "mielnica", caught in coastal waters in the Bay of Danzig with drift-nets and seines.
3) 7,780 Kg. sea-trout taken in the seine catches in the Bay and on the Baltic and in some part mixed with the drift-net "mielnica" salmon.

The total value of this catch over 3 years amounted to 990,823 zlotys (about £ 35,387).

For estimating the approximate number of large salmon caught we employed our data from the catches of 1931 as to weight at particular lengths and A. Willer's data (2) as to the weight of salmon caught by lines from the coast of East Prussia. Willer's analysis of line-caught salmon for 1929 showed the average weight as 8 Kg., which accords more or less with our data for 1931. We can take 400 g. as the average weight for small "mielnica" salmon. The average weight of sea-trout does not exceed 1.5 Kg., taking into consideration our former analysis of the sea-trout of the river Reda and the absence of large Dunajec sea-trout in sea catches.

One can estimate, then, as being caught in the Polish sea during the three years 1931—1933:

1. Large Salmon	25,147
2. Small salmon	128,800
3. Sea-trout	5,186

For this period, therefore, the stock of *Salmo salar* lost 153,947, that of *Salmo trutta* 5,186 individuals.

The size of fish.

Grouping the 364 drift-net salmon examined by us according to overall body-length we obtain the following numerical proportions.

Length of body in cm.	Percentage of fish 1931	1932	1933	Mean percentage for the 3 years
< 70 cm.	1 (1)	1 (1)	3 (3)	1
70—79 „	7 (12)	30 (27)	33 (32)	23
80—89 „	51 (90)	43 (39)	27 (26)	40
90—99 „	20 (36)	10 (9)	14 (14)	15
100 cm. and more	22 (37)	16 (14)	24 (24)	21
	(176)	(90)	(98)	

Figures in brackets denote the number of fish on which the percentage is based. The greatest number of fish falls into the group from 80 to 89 cm. (40 %). Fish of over 90 cm. account for 36 % and fish from 70 to 79 cm. only 23 %. Salmon of less than 70 cm. are very rare, only 4 having been obtained among the 364 specimens taken for examination.

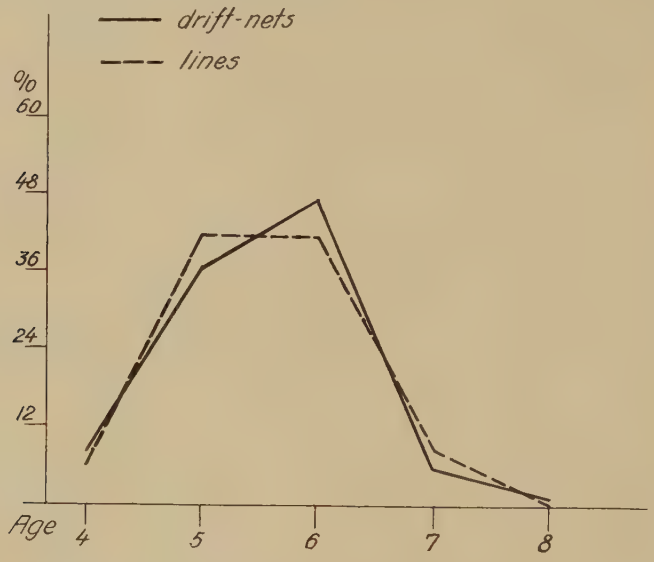
The numerical proportion of salmon of different sizes is different for those caught by lines, as appears both from our analysis and from that of Willer (2) for East Prussian catches in 1929.

Length of body in cm.	Percentage of fish 1928	1933	Willer 1929	Mean percentage
< 70 cm.	7	5	—	4
70—79 „	10	19	17	15
80—89 „	10	12	13	12
90—99 „	30	27	40	32
100 cm. and over	43	37	30	37

Those of over 90 cm. are in the majority, amounting to 69 %, as against the 36 % of drift-net salmon. The largest line-caught salmon in 1933 measured 130 cm., the smallest drift-net salmon 65 cm.

Age.

Further analysis of the catches of the last three years with regard to age shows no important changes in the salmon stock caught with drift-nets and lines. The following table shows the percentages at various ages among the 464 salmon taken for analysis:



Age	Drift-nets					Lines		
	1928	1931	1932	1933	Mean percent.	1928	1933	Mean percent.
4 years	7	1	16	3	7	7	6	6
5 „	25	50	36	40	38	27	57	42
6 „	65	37	42	47	48	53	30	42
7 „	3	10	5	7	6	10	7	9
8 „	—	2	1	3	1	3	—	1

As in 1928, the five and six-year old fish remain in the majority, amounting to a mean percentage of 84 %. Older fish of 7 to 8 years come second with 6 to 9 %, and four-year old fish amount to only 6 to 7 %. A certain diminution of the age of the stock may be observed since 1928 and in the last three-year period five-year old fish rose from 25 % to an average of 45 %, fluctuating in different years from 36 to 57 %.

A notable feature in the grouping according to age is the complete absence of three-year old fish, which take part in the shoal migration, for instance, in the Scottish salmon rivers. Another striking feature of the composition of the stock is the small proportion of four-year

old fish, amounting to an average of only 7 % or 6 % (drift-nets and lines) for the four 4 years. Only in 1932 the proportion of four-year old fish rose to 16 %, in the remaining years it fluctuated between 1 and 7 %. For comparison with these figures we have the data of the Swedish investigators, Alm (3) and Rosén (4), based on material from the southern and northern rivers of Sweden, and the data from Scottish rivers of Menzies and Macfarlane (5, 6). In the Mörrumsâ (in the province of Blekinge), which flows into the Baltic near Carlshamn on the southern coast, the percentage of four-year old fish amounted to 44 %. In the Scottish rivers Spey and Dee, according to the data of Menzies and Macfarlane, the percentage of four-year old fish varied in different years from 40 to 57. There is a completely different proportion in the rivers of the Bay of Bothnia, such as the Ume and Lule; there the percentage of four-year old fish is as low as 8, as the great majority of salmon going for the first time with the shoal (82 %) has been already 3 years in the sea.

H. Thompson's analysis (7) of the salmon catches in Newfoundland waters shows a similar result. Arranging the various points on the Newfoundland coast from north to south we have the following percentages of four-year old salmon.

Battle Harbour	4.6 %
Notre Dame Bay	17 %
Bonavista	13 %
Avalon	14 %
South Coast	31 %

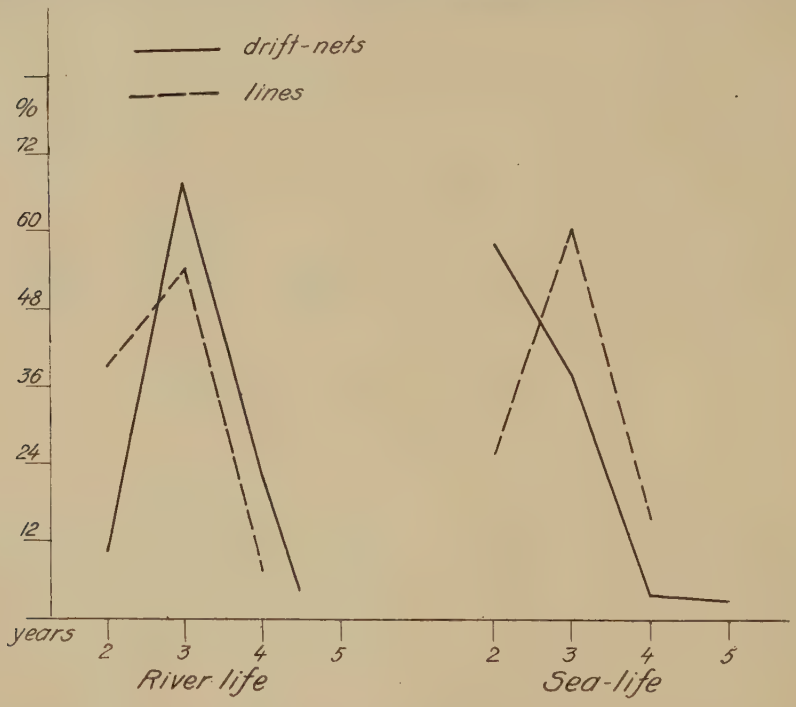
A comparison of the above-quoted data with the data obtained from our analysis leads to the supposition that the stock of salmon in the Polish Baltic belong to the group which lived in the northern rivers of the Baltic. This supposition is further strengthened by the large proportion of six-year old fish, a large percentage of which in the shoals is peculiar to the salmon of northern rivers. These fish are characterised also by a long period of river life.

Life in river and sea.

The following table gives the periods spent in river and sea by 464 drift-net salmon and 97 line-caught salmon according to our analysis of scales:

Number of years	River life				Sea life				Number of fish examined
	2	3	4	5	2	3	4	5	
Percentage of Fish									
Drift-nets 1928....	14	69	17	—	33	65	2	—	100
« « 1931....	5	70	25	—	70	22	7	1	176
« « 1932....	15	51	33	1	73	26	1	—	90
« « 1933....	6	77	16	1	53	40	3	3	98
Average	10	67	22	1	57	38	3	2	464
Lines 1928	40	47	13	—	17	63	20	—	30
« 1933	39	61	—	—	32	57	11	—	67
Average	39	54	7	—	25	60	15	—	97

There is, then, no great change from the state of 1928 in the period of river and sea life. For the four years together fish with a three or four-year period of river life amount to an average of 89 % of the whole catch, almost the same percentage as in each year separately considered. Among the line-caught salmon, however, is to be observed a far larger percentage with only a two-year river period. In our first paper, based on the analysis of the 1928 material, we emphasised the divergency between 14 % of two-year old drift-net smolts and 40 %



of line-caught salmon, but we ascribed this discrepancy to the paucity of our material. Now we have once more 39 % of two-year old smolts (for 97 fish examined) which encourages the supposition that line-caught salmon caught in the winter must come from rivers other than those from which the drift-net spring salmon come. The investigations of the next few years may elucidate this question; at present we can merely remark a large difference between the lengths of river life of drift-net and line-caught salmon.

A notable feature of the data concerning the sea-life of salmon is the complete absence of specimens having been only one year in the sea. This group apparently does not unite with the drift-net and line-caught salmon and the course of its migrations in the Baltic is at present not known. The comparison of the periods of river life of our salmon and that of certain Swedish rivers (Rosén, Alm) appears as follows:

Place where caught	River Average years in %				Sea Average years in %				
	2	3	4	5	1	2	3	4	5
Rivers Ume and Skellefte..	54	43	3	—	2.1	17.8	75.9	0.7	—
Polish Baltic:									
Lines	39	54	7	—	—	25	60	15	—
Drift-nets	10	67	22	1	—	57	38	3	2

As may be seen, the salmon caught in the Polish Baltic, especially spring drift-net salmon, differ considerably from the Swedish. Fish with 3 or 4-year periods of river life comprise the largest group of our drift-net salmon (61 % and 89 %), whereas in the north Swedish rivers 3 and 4 year-old smolts account for only 46 %.

Growth: calculated length in cm.

In order to give an idea of the growth-rate, we give the data in cm. of the four years separately, worked out by back-calculation with E. L e a's board, (see Table A).

We give below the average figures for the four-year period in order to simplify these data:

Calculated length in cm.; average for 4 years.

Periods Numbers of years	River 1	2	3	4	5	Sea 1	2	3	4	5
Drift-nets										
2-year smolts	5	11.3	—	—	—	40.3	77.4	97.2	107.5	113
3- „ „	4.3	9.0	14.6	—	—	43.4	78.3	97.0	107.1	107
4- „ „	3.7	7.3	11.4	15.8	—	46.0	80.9	97.5	104.4	—
5- „ „	2.6	5.6	8.7	13.3	17.8	36.0	74.1	—	—	—
Lines										
2-year smolts	5.2	11.7	—	—	—	40.9	74.2	95.7	114.4	—
3- „ „	4.1	8.2	14.2	—	—	44.2	74.5	101.1	110.2	—

There is no great divergence noticeable between the growth-rates of drift-net and line-caught salmon either during their period of river or sea life. The growth increments of parrs varies according to the length of river existence from 2.6 to 5.2 cm.; that of smolts from 11.3 to 17.8 cm. The data given confirm also the already known fact that the longer the period of river existence, the smaller the rate of growth during the period of existence in the sea. In this respect the following average lengths for fish of various ages appear from the material analysed:

4-year	old	with	2	years	river	life	.....	77	cm.
5- „	„	„	2	„	„	„	.....	99.3	„
5- „	„	„	3	„	„	„	.....	79.8	„
6- „	„	„	3	„	„	„	.....	96.9	„
6- „	„	„	4	„	„	„	.....	81.9	„
7- „	„	„	2	„	„	„	.....	115	„
7- „	„	„	3	„	„	„	.....	102	„
7- „	„	„	4	„	„	„	.....	97.6	„

Table A.

	No. of years	Drift-net 1928	1931	1932	1933	Average	Lines 1928	1933	Average
2-year smolts									
River	1	4.9	6.0	4.5	4.6	5.0	5.4	5.0	5.2
„	2	11.7	11.3	11.8	10.6	11.3	11.5	12.0	11.7
Sea	1	40.3	40.0	44.6	36.4	40.3	37.6	44.3	40.9
„	2	73.0	77.0	83.5	76.2	77.4	71.3	77.1	74.2
„	3	91.0	99.5	97.0	101.2	97.2	91.8	99.7	95.7
„	4	106.0	—	—	109.0	107.5	106.1	122.7	114.4
„	5	—	—	—	113.0	113.0	—	—	—
3-year smolts									
River	1	4.9	4.6	3.9	3.9	4.3	4.4	3.9	4.1
„	2	9.1	9.3	8.4	9.2	9.0	7.8	8.7	8.2
„	3	15.7	15.4	13.2	14.0	14.0	13.9	14.5	14.2
Sea	1	43.1	44.3	44.6	41.7	43.4	43.1	45.4	44.2
„	2	75.0	82.7	79.7	76.0	78.3	76.8	72.2	74.5
„	3	—	98.0	99.8	93.1	97.0	98.9	103.4	101.1
„	4	—	108.0	108.0	105.3	107.1	—	110.2	110.2
„	5	—	—	—	107.0	107.0	—	—	—
4-year smolts									
River	1	4.3	3.5	3.5	3.6	3.7	—	—	—
„	2	8.0	7.4	6.6	7.2	7.3	—	—	—
„	3	12.1	11.4	10.9	11.4	11.4	—	—	—
„	4	16.8	16.2	14.3	16.1	15.8	—	—	—
Sea	1	47.8	45.9	45.5	44.7	46.0	—	—	—
„	2	83.0	83.0	74.0	83.8	80.9	—	—	—
„	3	102.5	92.4	94.1	101.1	97.5	—	—	—
„	4	—	104.4	—	—	104.4	—	—	—
5-year smolts									
River	1	—	—	1.6	3.6	2.6	—	—	—
„	2	—	—	4.8	6.5	5.6	—	—	—
„	3	—	—	7.6	9.8	8.7	—	—	—
„	4	—	—	11.3	15.3	13.3	—	—	—
„	5	—	—	14.5	21.2	17.8	—	—	—
Sea	1	—	—	38.0	33.9	36.9	—	—	—
„	2	—	—	73.3	74.9	74.1	—	—	—

Periods Numbers of years	River 1	2	3	4	5	Sea 1	2	3	4	5
2-year smolts	5	6.3	—	—	—	29.0	37.1	19.8	10.3	5.5
3- „ „	4.3	4.7	5.6	—	—	28.8	34.9	18.7	10.1	0
4- „ „	3.7	3.6	4.1	4.4	—	30.2	34.9	16.6	6.9	—
5- „ „	2.6	3.0	3.1	4.6	4.5	18.2	38.1	—	—	—

The dependence of the growth-rate in the sea on the length of river existence is, therefore, clear. A five-year old salmon developed from a three-year old smolt is larger, for instance, than a seven-year old salmon developed from a four-year old smolt. The Scottish

investigator Menzies considers the length at the end of the first year of life of a parr to be an index of its further growth. We give below his very concise conclusion: "A short parr makes a poor, or an old, smolt and makes a poor growth in the sea. A long parr makes a good smolt and grows well throughout its marine existence." (8).

Spawning marks.

Of the material analysed 15 % of the drift-net salmon and 22 % of the line-caught were found to possess distinct spawning marks. The period of marine existence preceding the first spawning migration is as follows:

1	year	marine	existence	preceding	the	first	spawning	.... 16 %
2	„	„	„	„	„	„	„	.... 62 %
3	„	„	„	„	„	„	„	.... 22 %

One year of marine existence before the first spawning migration is found usually among salmon with a 4-year river existence, that is, five-year old fish. The greatest number (62 %) have a two-year marine existence prior to spawning. Those with a two and three-year period amount together to 84 %.

Our four years analysis of average specimens caught in the Polish Baltic gives the following results:

1. Up to 84 % of drift-net stock are 5 or 6-year old fish.
2. The proportion of 4-year old fish (except in 1932, when there were 17 %) fluctuates between 1 % and 7 %.
3. With regard to length of body 36 % of the drift-net salmon are large (from 90 to 100 cm. and over), 40 % from 80 to 89 cm. and 23 % from 70 to 79 cm.; salmon of less than 70 cm. are caught very rarely.
4. Line-caught salmon differ from those caught in drift-nets in containing a high proportion of large salmon, over 90 cm.; this proportion amounts to 65 %.
5. 67 % of the stock of drift-net salmon have had a three-year river existence, 22 % a four-year and only 10 % a two-year.
6. The line-caught salmon with a two-year river existence amount to 33 %, three-year 54 %; that is to say, fish with a two or three-year river existence predominated.
7. The majority of the drift-net salmon have a two-year marine existence, the majority of line-caught a three-year.
8. Among both drift-net and line catches there is a complete absence of specimens with a one-year marine existence.
9. The considerable difference between the periods of river and marine existence of drift-net and line-caught salmon leads to the supposition that these come from different rivers.
10. Salmon caught in the Polish Baltic first spawn after two or three years of marine existence.

Analysis of small salmon, so-called "mielnica".

The extremely small salmon known to the fishermen as "mielnica" occupy a completely separate place among the salmon caught in the Polish Baltic. We have found no reference to material analogous to our "mielnica" in literature devoted to the growth-rate and age of salmon. This uncommonly small and long-lived salmon, very rarely attaining the length of 50 cm., is bound to create some confusion in the international discussions for establishing a minimum size of salmon to be caught.

Neither does the river material which forms the principal subject of analysis of Baltic salmon in the Swedish rivers (by Alm and Rosén) provide any parallel with our "mielnica". The data given below serve to show that the stock of small and long-lived "mielnica" belong to a different race of salmon coming from far northern rivers, and must be treated quite separately in any general legislation as to the measurements of salmon which may be caught.

Length of body.

We carried out in 1928 our first analysis of "mielnica" working on material from the catches of 1925, and published the results in "Journal du Conseil" (1931, No. 3). The material of 1925 consisted of 70 specimens of "mielnica" caught in the littoral waters of the Bay of Danzig with driftnets of 34—35 mm. mesh. There were no fish of less than 38 cm. caught in 1925. The material of the present year was taken from our Marine Station gill-net catches, and the results of analysis with regard to age and growth were completely different.

The proportion of specimens of various sizes was as follows:

Length in cm.	33	34	35	36	37	38	39	40	41	42	43	44
Number	1	1	10	13	21	15	14	9	7	5	3	1

That is to say, 84 % of the specimens were of 33 to 40 cm. and only 16 % of 40 to 44 cm. There was no single specimen of as much as 50 cm., as also was the case among our material for the year 1925.

Age.

Comparing the material for the years 1925 and 1933, we discovered that, leaving out of consideration the preponderance of small fish of less than 40 cm., the average specimen of 1933 is older than that of 1925. The following table illustrates this.

	1925	1933
4 years old	80 %	15 %
5 „ „	20 %	53 %
6 „ „	—	32 %

Six-year old fish, which were entirely lacking in 1925, amount now to 32 % of the whole catch, five-year old fish have risen from 20 to 53 % and four-year old decreased from 80 % to 15 %.

River and Marine Periods.

Such a change in the age of the catches could be due, taking in consideration the fact that all "mielnica" without exception had one year of marine existence, only to a lengthened period of river life. Indeed a comparison of the material of 1925 with that of 1933 affords the following data:

Number of years spent in river and sea.

Periods	River			Sea
Number of years	3	4	5	1
Percentage of Fish				
1925	60	20	—	100
1933	15	53	32	100

We have, then, in the material of 1933, a new group of five-year old smolts amounting to 32 % of the whole. The number of four-year old smolts has risen to 53 % and the three-year old group fallen to 15 %. Specimens with two years of river existence are still completely lacking. The characteristic features of "mielnica", then, still continue — complete absence of two-year old smolts and a one-year marine existence.

Back-calculation of length, in cm.

The length of the fish obtained by the E. Lea method, and the yearly increment in cm. show the following growth-rates for the river and sea life of "mielnica":

Periods	River life					Sea life
Number of years	1	2	3	4	5	1
3-year old smolts	4.2	9.4	15.5	—	—	37.7
4- „ „ „	3.6	8.0	13.1	19.6	—	38.5
5- „ „ „	3.1	6.8	11.0	15.4	22.2	38.4
	Yearly increments in cm.					
3-year old smolts	4.2	5.2	6.1	—	—	22.2
4- „ „ „	3.6	4.4	5.1	6.5	—	18.9
5- „ „ „	3.1	3.7	4.2	4.4	6.8	16.2

There is no striking divergence between the growth-rate of mielnica and drift-net salmon during the river period. The average growth increment of "parrs" and smolts, dependent on the age of the smolts, varies as follows:

	Parr	Smolt
Large drift-net salmon	2.6 to 11.4 cm.	14 to 17.8 cm.
„ „ „ mielnica	3.1 „ 13.1 „	15.5 „ 22.2 „

The average growth-rate of mielnica in the river period is, then, even greater than that of large drift-net salmon. Particularly remarkable is the considerable growth during the last year of river life, amounting for all three groups, 3, 4 and 5 year smolt, to over 6 cm., whereas for large salmon it fluctuates between 4.4 and 5.5 cm. A study of the scales of mielnica explains this. The winter ring for the last winter of the smolt in the river is always far removed from the former river periods. There is no doubt that mielnica-smolt spend their last river year in more fertile waters or at the river-mouth or even in brackish water. This paradoxical fact of normal river growth-rate coupled with the uncommonly small measurements of 4, 5 and 6-year old fish with one year of sea life is contradictory to the established fact of the influence of river life on a salmon's subsequent growth in the sea. But our calculations show the growth of mielnica of 3, 4 and 5 years of river life during their first marine year to be much less than that of large salmon.

	Large salmon		Mielnica	
	Length in cm.	Increment in cm.	Length in cm.	Increment in cm.
3-year old smolts	43.4	28.8	37.7	22.2
4- „ „ „	46.0	30.2	38.5	18.9
5- „ „ „	36.0	18.2	38.4	16.2

The figures illustrating growth in the sea show that the small size of mielnica is probably due to poor feeding conditions and possibily also to the physical conditions in the sea.

In any case the fact remains that the size of 4, 5 and 6-year old mielnica varies between 33.5 and 44 cm. A comparison of the size of these ages with large salmon appears as follows:

Age	Length in cm.	
	Large salmon	Mielnica
4-year old with 2 years river-life	77.0	none
4- „ „ „ 3 „ „ „	—	37.7
5- „ „ „ 2 „ „ „	99.3	none
5- „ „ „ 3 „ „ „	79.8	none
5- „ „ „ 4 „ „ „	—	38.5
6- „ „ „ 3 „ „ „	96.9	none
6- „ „ „ 4 „ „ „	81.9	none
6- „ „ „ 5 „ „ „	—	38.4
Average length	87.0	38.2

4, 5 and 6-year old "mielnica", then, independently of the number of years spent in the river, are about the same average size, from 34.4 to 38.5 cm. After completing their second or third year of sea life, the increment in which we do not know, the mielnica must migrate for spawning and probably some of them spent the autumn of 1933 in their native river.

Dissection of 30 mielnica females and 13 males served to establish this, as the state of the gonads in the upper part of the belly, and

the fact that a salmon's gonad develops in the course of a year, pointed to the autumn of 1933 as the first spawning time.

In order to make further biological investigations concerning this small salmon the Marine Station this year marked mielnica caught in gill-nets. The recovery of any of these mielnica and the return of the mark with scales and length measurements would inform us of their place of spawning and further growth-rate in the ensuing marine life[1]).

At present, on the basis of the investigations already carried out we can only assert the complete difference of the groups of large salmon caught with drift-nets and lines from the mielnica. This difference for the 1933 material may be summarized as follows:

	Large salmon	Mielnica
	I. Age	
4-year old fish, percentage	6	16
5- „ „ „ „	39	53
6- „ „ „ „	45	32
7- „ „ „ „	7	—
8- „ „ „ „	2	—
	II. Average length in cm.	
	87	38.2
	III. River life	
2-year river life, percentage		
drift-nets	10	
line-caught	33	none
3-year river life		
drift-nets	67	15
line-caught	54	
4-year river life		
drift-nets	22	53
line-caught	13	
5-year river life		
drift-nets	1	32
line-caught	none	
	IV. Sea life	
Number of years in the sea:		
drift-nets and lines	2 to 5	1

The difference between large salmon and the mielnica group is further illustrated by the fact that fluctuations of catches of the former do not correspond with those in catches of the latter. The statistics for the last 4 years show that an increase in the catches of large salmon is accompanied by a decrease in the catches of mielnica, and vice versa.

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Über die Verteilung von *Mallotus villosus* im Barentsmeer.

Von

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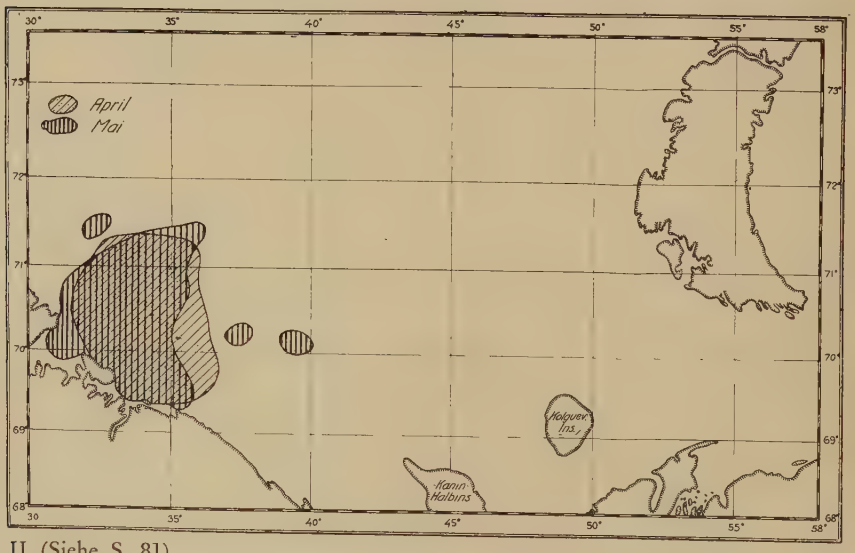
DAS Problem der räumlichen und zeitlichen Verteilung der Fische, anders gesagt, das Problem der Wanderung der Fische ist von enormer Bedeutung; es muss jedoch anerkannt werden, dass die Aufklärung der Frage des öfteren mit sehr bedeutenden Schwierigkeiten verbunden ist und grosse Kosten erfordert. In einigen Fällen aber und zwar bei gut entwickelter Fischerei, wo dabei mehr oder minder regelmässige Untersuchung der Fänge ermöglicht ist, lassen sich parallel zahlreiche äusserst wichtige Daten von grossem Interesse ermitteln.

Welch höchst interessantes Material stellt z. B. die Nahrung des Kabeljaus dar. Ich besitze derartiges in verschiedenen Jahren gesammeltes Material, das sich auf die Ernährung des Barentsmeer-Kabeljaus bezieht. Auf Grund dieses Materials habe ich den Versuch gemacht, die Frage der Verteilung von *Mallotus villosus* im offenen Meer aufzuklären. Wie sich erweist, kommt diesen Fischen eine bedeutende Rolle in der Ernährung von *Gadus morrhua (callarias)* zu, ein Umstand, der das Interesse für diese Art in grossem Masse erhöht.

Aus den beigefügten vier Karten lässt sich die Verteilung von *Mallotus villosus* im südlichen Teile des Barentsmeeres zu verschiedenen Jahreszeiten ersehen. Im Januar ist der Fisch noch nicht zahlreich. Einzelne Schwärme ziehen vom Osten her dem Südwesten zu und begeben sich teilweise sogar in südlicher Richtung, der Insel Kyldin und der Halbinsel Rybatschij sich nähernd. Im Februar bewegen sie sich in eben derselben Richtung, aber die Schwärme werden dichter und dabei auch zahlreicher. Im Rybatschij und Kyldin Gebiete sammeln sich die Fische in ziemlich bedeutender Weise an. Ähnliche Ansammlungen werden ebenfalls gegen Finmarken und mitunter auch in nördlicher Richtung vorgefunden. Vielleicht gelangen die Schwärme dort hin nicht von Osten sondern direkt von Norden her. Im März und April hält sich *M. villosus* in dichten Scharen zwischen Finmarken, der Halbinsel Rybatschij und dem östlich von der Insel Kyldin gelegenen Gebiete im offenen Meer auf. In nördlicher Richtung tritt der Fisch um diese

I



II (Siehe S. 81).

Zeit bis zu 71°, ja sogar bis zu 71°30′ nördlicher Breite auf. Gegen April wird *M. villosus* entweder zahlreicher oder die Fische sind mehr zerstreut, da ihr Verteilungsgebiet grösser wird. Im Mai beginnt *M. villosus* sich nach allen Seiten hin zu zerstreuen, wobei die Schwärme teilweise eine nördliche Richtung einnehmen, hauptsächlich aber bewegen sie sich in östlicher Richtung vom Gebiete ihrer Hauptansammlungen aus.

Im Juni lässt sich ein Gebiet, das gleichmässig von *M. villosus* besetzt ist, so wie es im März, April und Mai zwischen Finmarken

III

IV

Karte der Verteilung von *M. villosus* im Barentsmeer während der Monate Januar—März (I), April—Mai (II), Juni—Juli (III), August—Dezember (IV).

und der Halbinsel Rybatschij beobachtet wird, schon nicht mehr ermitteln. Einzelne Schwärme halten sich noch nördlich von Kyldin und Rybatschij auf, andere begeben sich weiter nordwärts und ferner sondern sich von diesen und jenen wieder andere Schwärme ab, die sich in östlicher Richtung bewegen.

Äusserst interessant ist die Verteilung von *M. villosus* im Juli. An den Stellen, wo in den früheren Monaten die grössten Massen der

Fische auftraten, kommt diese Art jetzt nicht mehr vor. Die Fische sind weiter ostwärts gerückt. Vereinzelte Schwärme halten sich noch in ziemlicher Nähe der Küstenregionen auf, aber die meisten sind nördlich gerückt und sind auch weniger dicht geworden. Nach und nach zerstreuen sich die Fische immer mehr; dichte Schwärme werden selten. Im August haben sie sich nach allen Seiten hin zerstreut und treten sehr selten in grösseren Mengen auf. Solche Schwärme werden am Nord-Eingange der Meerenge, die das Barentsmeer mit dem Weissen Meer verbindet, angetroffen; mitunder werden sie östlich vom Cap Kanin-Meridian vorgefunden. Besonders eigenartig ist der Umstand, dass wir im August, unter anderen, *M. villosus* in unmittelbarer Nähe der Küste der Halbinsel Kanin — vorwiegend in der Region von Kanin Noss — vorfinden. Im September zerstreuen sich die Fische noch stärker als im August; nur vereinzelte sehr kleine Schwärme werden da angetroffen, wo sie im August vorkamen. Die Art lässt sich auch an den Ufern der Insel Kolguyew, vorwiegend an deren östlicher Küste, vorfinden. Im Oktober ist *M. villosus* am stärksten zerstreut und es ist unmöglich, irgend welche Gebiete ihres Vorkommens auf der Karte zu vermerken. Im November kommt der Fisch wiederum scharenweise vor, die Schwärme werden an der Küste der Nowaja Zemlja, bei der Insel Kolguyew, im Gebiete der Halbinsel Kanin und weiter in nordwestlicher Richtung angetroffen. Im December kommt *M. villosus* an den Stellen vor, die als die am meisten östlich gelegenen Punkte der Januaransammlung dieses Fisches festgestellt worden sind.

Dies also ist das Bild von der Verteilung von *M. villosus*. Es ist selbstverständlich nur in grossen Linien gegeben. Weiteres Material über die Ernährung von *Gadus morrhua* wird wohl noch mehr Einzelheiten des hier skizzierten Bildes der Wanderungen von *M. villosus* bringen.

Meines Erachtens ist es unzweifelhaft, dass diese Verteilung von *M. villosus* in direkter oder indirekter Weise mit der Verteilung der Temperaturen des Seewassers verknüpft ist, sie steht also mit den Strömungen und wohl auch mit der Verbreitung einiger Planktonorganismen in Zusammenhang. An der Hand aller dieser Daten wird es wohl, scheint mir, möglich sein, die entsprechenden Gesetzmässigkeiten ohne grosse Schwierigkeiten zu ermitteln. Wenn wir derartige Karten von *M. villosus* Migrationen für 2—3 Dekaden besässen, so liessen sich aus ihrer Zusammenstellung bemerkenswerte Schlüsse bezüglich der Periodizität und des Rhythmus verschiedener im Meere sich abspielender Erscheinungen ziehen.

Observations on the Accuracy of the Collection of Fishery Statistics.

By

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ARISING out of the question of the degree of accuracy that is achieved by the Collectors of Fishery Statistics in England, by the methods of collecting detailed in "A Short Account of the Statistics of Sea Fisheries" by T. Edser — Rapp. et Proc.-Verb. des Réunions Vol. XXXVI, a series of statistics is now available with which a critical examination of certain aspects of the question may be made.

It will be necessary briefly to recapitulate the explanation of the methods used as recorded in that publication. The Collector attends at the market place some time before the fish is sold, and obtains details of the catch of each vessel which he enters in his note book in terms of market weights or measures, chiefly from actual counting of the packages as they lie in the market ready for sale. These quantities have to be converted into cwt. by factors which are determined by actually weighing, from time to time, the contents of sample packages. These factors have to be used with considerable discretion as the packing of the receptacles is distinctly variable. The Collector has also to ascertain the value realised by the sale of the fish from observation, at the auctions, of the actual prices obtained for the individual parcels of each kind. He then applies the average price of each kind to the total of that kind ascertained by casting the items in his note book, and the aggregation of the values for each kind gives the total value for the day.

This is the general procedure, but for the port to which this test applies, it is necessary to add that it is customary to sell many of the varieties laid out in rows on the market floor, and consequently, the estimation of the weight of each lot, is very difficult. It will be appreciated that, as the collection has to provide data for consideration of other than purely economic questions, such for example as the relationship of catch to fishing power expended, it is essential that the weight should be the basis of the collection, otherwise it would be easier to always work in terms of value.

Another difficulty which faces the Collector is the selling arrangements which prevail between salesmen and buyers, such for instance as the final bid at auction usually applying to only a proportion of the quantity offered, the remainder being subject to a private deal between the parties: also it is customary to allow the purchaser a variable rebate, some 5 to 10 %, on the quantity he buys, and the auction bid has to be adjusted accordingly. There is also the custom of payment in kind, pilfering, and other irregularities, which all have the effect of reducing the amount of the quantities landed, already noted by the Collector, which are actually sold at auction, and, as will be seen later, this has a marked effect upon the test comparison.

The independent figures which we have used for this test were obtained through the courtesy of the trawler owners. They have been good enough to supply for most of the landings during a period of about 7 years, the "grossings", i. e., the total sale value of the fish landed and sold for each landing. Owing to some details not being available, it was not always possible to obtain the grossings for all vessels landing on a particular day, and for such days no comparison was made. To explain why these were omitted it must be appreciated that evaluating the individual landings by the average prices may result in big differences, particularly when, as frequently happens, the quality of the fish landed by different vessels varies considerably. This is illustrated by the landings on a particular day detailed below. In the column headed "Grossings" is shown for each vessel the total sale value of that landing as supplied by the owner, and the next column shows what the same landing would have realised if the day's average values had been applied to the quantity of each kind landed by the vessel. In actual practice this it not done, the averages only being applied to the total landings.

Vessel	Grossings £	Total by Average Prices	Percentage Difference
1	537	614	+ 14
2	394	377	— 4
3	127	119	— 6
4	108	96	— 11
5	108	104	— 4
6	24	21	— 12
7	64	65	+ 2
8	61	60	— 2
9	18	13	— 28
10	82	79	— 4
Total	1,523	1,548	+ 2

Vessel 1 was from a distant region and landed fish of an inferior quality, yet despite the large disparity with her grossing which the average method would cause, the total for the day shows a difference of only + 2%. If, however, the comparison had been made excluding this vessel, the comparative figures would have been £ 986 against £ 934, a difference amounting to — 5 %.

Actually over 13,000 landings spreading over 978 days and grossing £ 1,040,285 have been used in this comparison, the Collectors' total being £ 1,061,429, an excess of 2 %. The 13,000 landings represent more than half of the total landings during the period under review.

It will now be apparent that we are comparing a series of 978 sets of two daily totals, one obtained by tabulating the quantities of each kind landed during the day and applying thereto average prices derived from observation of the market and the actual sales after making due allowances for auction customs, and the other (the sum realised for the fish landed and sold) from the total of the owners' returns of each vessel's grossing. The difference each day has been reduced to a percentage of the latter, and these percentages in groups of 0.5 % are shown in the following table

Difference Per Cent	No. of Days	Difference Per Cent	No. of Days
— 2.0 or more.	1	+ 3.0	101
— 1.5	2	+ 3.5	58
— 1.0	4	+ 4.0	38
— 0.5	15	+ 4.5	16
0.0	39	+ 5.0	5
+ 0.5	70	+ 5.5	7
+ 1.0	112	+ 6.0	5
+ 1.5	164	+ 6.5	1
+ 2.0	180	+ 7.0 or more.	2
+ 2.5	158	Total	978

This distribution is clearly a balanced one around a mean at about + 2.0 which means that the Collectors' figures tend to be consistently that amount above the grossings. As explained above, it was found that a certain amount of the fish landed failed to appear at the auction sale, and a careful estimate made in 1930 placed the amount at between 2 and 3 % of the total landing, but since that date various steps have been taken to reduce some of the irregularities, and although they have not been completely eliminated yet they have been considerably reduced.

For strict comparison therefore it is necessary to add an amount of about 2 % to the grossings which amounts practically to deducting 2.0 from each difference in the above table. If this be done the distribution indicates that in half of the comparisons there is agreement within a range of ± 0.75 % of the total value and that on about 90 % of the days the agreement is within + 1.75 % of the total value. Furthermore, it is evident from the way the occurrences are balanced around the mean that where daily totals are combined to produce longer periods, such as a month, the individual errors will balance themselves out and the result will be strictly in accordance with actuality.

Since the total value has thus been proved to have such a high degree of reliability, it follows that each of the steps by which it

was obtained must be accurate to a corresponding degree. (It is inconceivable that only compensatory errors should consistently appear and any other errors would disclose themselves by falsifying the total value).

Therefore we may conclude that the collection in so far as it deals with the conversion from market weights and measures into cwt. and with arriving at the average value per cwt. of each kind of fish is also substantially accurate.

The Physical and Chemical Oceanography of the Irish Sea. A Bibliography.

By

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THE accompanying list of references to hydrographical work on the Irish Sea was originally drawn up as a card catalogue for the convenience of workers in the Department of Oceanography at the University of Liverpool. It seems possible, however, that it may be of wider interest. It has been classified under the headings used in the Current Bibliography in this Journal.

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[1]) Brackets round page numbers indicate references to areas just *outside* the Irish Sea.

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Correspondence.

Plymouth Sagitta.

Dear Sir,

IN Vol. VIII, No. 3 of this Journal on pp. 401—402 two recent papers of mine on the biology of Sagitta were reviewed. In justice to the Plymouth Sagitta I think it should be pointed out that some of the conclusions given in this review bear no relation to the conclusions given in my own papers. One of the main points made in the review is that there is a dispersal of the small stages and a congregation of adults at maturity and the dispersal "phase is indicated by the small numbers captured in the plankton nets". I find at the bottom of the first page of my second paper the following sentences: "It is, however, necessary to point out that this distribution relates only to a population such as is sampled by the stramin material of which the ring-trawl is made. On the whole, therefore, the majority of the early stages, probably from about 7 or 8 mm. in length and less will be missing." While Professor M e e k has in his own work suggested that there is a "cross-current" migration at maturity, I have myself up to the present found no evidence for such a conclusion in Plymouth waters, nor have I ever suggested that the early stages are more dispersed than the adult. I fear that my use of the word "dispersion" in the analysis of the curves of length variation has been misunderstood. In my first paper I say "It was clear that while the February curve for *S. elegans* showed very little variation in size for the majority of the population caught, the population in May tended to be very widely dispersed. In *S. setosa*, on the other hand, there was a gradual narrowing down of the dispersion until a spawning population with little variation in length was produced by May." In the review these remarks appear to have been misconstrued as follows: "The remarkable feature is the apparent disappearance or almost complete disappearance of the young stages (of *S. setosa)* from the spawning zone. So complete a dispersion of the young was not seen in the case of *Sagitta elegans*, but still the results show that their numbers undergo a diminution." In my opinion also the reason why we see a diminution in the numbers of the smaller size is because those that survive are growing larger, and not because they are more dispersed over the area.

Yours faithfully

F. S. Russell.

The Laboratory,
Marine Biological Association,
Plymouth.

Migration of Fishes.

Dear Sir,

WHEN we receive a book by a professor of natural history we approach it with the feeling that we have an authoritative work based on facts ascertained and proved with the precision normal to any science. In this present work[1]), however, that precision is lacking. We are not warned that it is a philosophic discussion based on possibilities, and in the end we are left with a feeling of definite doubt and some disappointment.

Professor R o u l e founds his outlook on the migration of the fishes which spend part of their life in fresh water on the supposition that the oxygen content of the medium is the all-directing influence which controls their movements. On this supposition he brushes aside many of the known facts of the life of the Atlantic salmon *(Salmo salar)* and substitutes for these an imaginary journey of his own making, in support of which he advances no observations and no facts which would bear out his contentions.

With due warning it is presumably open to any of us, professor of natural history or otherwise, to construct theoretical programmes, and for such theories, if submitted with authority of sufficient weight and backed with a sufficiency of relevant facts, we are bound to have respect. Apart altogether from supporting his theory with known facts, the other alleged facts which Professor R o u l e quotes, we can only presume at second-hand, do not always have that accuracy which is so necessary for any work as a whole to be regarded as authoritative. For instance, he is, as in the case of the brown trout, entirely in error in supposing that the male salmon assist at all in the construction of the redd in which the eggs are laid. There is also no reason to suppose that these fish ever willingly spawn on a sandbank, as he suggests. He also appears to believe that the whole of the salmon spawn in the upper tributaries of a river and entirely ignores the fact that many of the summer fish spawn in the middle areas. The late coming autumn fish, entirely oblivious of his theory of the superior oxygenation of the waters of the upper reaches, may actually spawn within the reach of the tide and entirely refute his statement that there is no sign of the fish maturing when in the sea, since they may come into fresh water with ova and milt at any stage of development up to that of complete ripeness. His observations that the males rub off their scales when spawning is no more correct than that the absorption of the scales is due to wear at the same period. Anyone who has tried to extract scales from the skin of a ripe male, or a male kelt, knows how impossible it would be for them to be rubbed off, and a minimum amount of material taken throughout the season would have shown him that absorption may start quite early in the year, at least nine months before the spawning period, and that, in the case of male fish,

[1]) Fishes — Their Journeys and Migrations: by Louis Roule. London, 1933.

it may progress to such an extent as to destroy the greater part of the scale before spawning commences.

It is perhaps excusable that the misstatement that nearly all grilse are males should be repeated, although in fact one third of them in Scotland anyhow are females, but the conjunction of fish weighing from 11 to 22 pounds with a length of from 20 to 30 inches is an error of greater magnitude, since the correct length should be from 30 to 40 inches. In spite of the assertion made in this volume, kelts do not feed regularly in fresh water; an occasional specimen may do so, but it is the exception, and the giant salmon are not fish which have spawned many times but normally those which, although comparatively young, have spent the whole of their life feeding and growing and have never spawned. Before leaving matters of detail it is perhaps desirable to point out that salmon are caught in the sea and are not captured in rivers alone; for instance the majority of the commercial catch of Scotland is taken on the open coast of that country.

Here are some further points of detailed criticism. Male trout do not make the redd or nest for the eggs as Professor Roule alleges, nor does his description of a redd accord with the actual facts. Similarly trout in a lake without spawning tributaries do not become sterile in the ordinary sense; they may become egg-bound, or, to adopt a word from salmon phraseology, baggots, but if the conditions are suitable in the slightest degree the whole ripe population will spawn along the edges of the lake. I have seen literally hundreds doing so on many occasions. I can also assure the author that trout in fish farms do hunt each other and, if the sizes are not carefully segregated from time to time during the first two or three years of life, the larger trout will consume the smaller, even of exactly the same age, and heavy losses of stock will inevitably result.

Professor R o u l e has a picturesque imagination to which he gives free rein and it is a pity that one has to be critical about a book written in such happy phrases and delightful prose, and, may I add, translated with such skill and discretion, the only error perhaps being "vesiculated fry" instead of the more familiar "alevin". Picturesque as his imagination may be, however, he surely scarcely expects us to believe that the salmon of France feel at a distance of "hundreds of miles" from the mouth of any river the influence of the fresh water and are impelled thereby to return to the stream having the greatest percentage of oxygen. Not only records of marked fish but also all the evidence deduced from the scales points indubitably to a most definitely exact homing instinct. Nor can he expect us to consent to the supposition that salmon may spend 7, 8 or 9 years in the sea, when this statement is unsupported by evidence; the longest continuous residence (and that quite exceptional) of which we have record is 5 consecutive years. His further statement that the sea is populated to some extent with salmon of miraculous size which have failed to find the freshwater urge to return is equally unsupported. Again unfortunately his ingenious imagination of the consumption of *Acanthephyra*

purpurea as a staple form of diet does not accord with the fact that herrings and sandeels are the most common form of food found in the stomachs of salmon off the coast of Great Britain or with their known feeding habits in the Baltic.

Professor R o u l e evidently finds himself at variance with such an eminent authority as the late Professor S c h m i d t when he says that the American elvers enter fresh water at two years of age.

With the chapters of the book devoted to fish of exclusively marine habit, as the herring, mackerel, sardine and tunny, I leave others more learned in those fishes than I, to deal.

Yours faithfully,

W. J. M. Menzies.

Fishery Board for Scotland,
Edinburgh.
14th November, 1933.

Cher Monsieur,

JE vous remercie de m'avoir donné l'occasion de répondre à l'analyse de mon ouvrage par M. M e n z i e s. Je me suis imposé la règle de ne point riposter aux critiques. J'estime que c'est là, fort souvent, du travail et du temps perdus. Dans la science de documentation, on ne répond à des faits que par d'autres faits; et, comme il est impossible à un seul homme d'élucider un problème, le temps se charge de donner la critique effective. Pourtant, je fais une exception pour M. M e n z i e s, en raison de sa notoriété sur les questions relatives au Saumon.

L'ouvrage analysé est une traduction anglaise récente (1933) de mon volume d'études ichthyologiques, consacrées aux migrations des Poissons, publié en 1929 dans son texte original de langue française. Sans m'arrêter au préambule du texte de M. M e n z i e s, je me demande pourquoi son auteur n'a rien dit de mon premier chapitre, où j'expose, sous le titre "Le problème des migrations", la méthode biologique que j'ai suivie afin d'aboutir à une explication possible de ce que l'on nomme l'instinct migrateur. Ce chapitre éclaire tout l'ouvrage. Aussi la critique de M. M e n z i e s, en le laissant de côté, se trouve-t-elle fort incomplète. Elle ne donne point exactement l'appréciation qu'il faudrait.

Je me demande en outre pourquoi M. M e n z i e s, qui est homme de science, et qui doit être nécessairement au courant de la bibliographie concernant le Saumon, ne s'est point rappelé mes travaux techniques, dont le plus important, intitulé "Etude sur le Saumon des eaux douces de la France", a paru en 1921. Le volume actuel en est la suite, et le résumé synthétique. Les scrupules préliminaires de M. M e n z i e s en eussent été atténués.

Du reste, M. M e n z i e s, négligeant ainsi le fond, se borne à feuilleter par places, au cours des pages, et à relever divers détails qu'il

mentionne seuls. Pour cela, il prend une ou plusieurs phrases, les isole de ce qui les précède et les suit, ce qui les déforme. Aussi me fait il exprimer des choses qui ne sont pas les miennes. S'il avait lu avec attention, s'il avait consulté mes mémoires techniques sur le Saumon de France, il ne m'aurait jamais attribué la paternité de ce qu'il avance comme m'appartenant. Le curieux en cela, c'est que cette critique parait défendre contre moi des notions que j'ai contribué à établir, comme la nécessité, pour les pisciculteurs, de séparer les Truites de tailles différentes, l utilité de l'étude approfondie des écailles du Saumon, l'erreur d'admettre que les grands Saumons ont accompli plusieurs migrations successives de va-et-vient du milieu thalassique au milieu potamique, la rapidité de la croissance du Saumon en mer, etc.

D'ailleurs, la critique de M. Menzies affecte d'employer à mon égard les termes d'imagination, d'hypothèse, d'idée, de défaut de précision, comme s'il s'agissait de vues de mon esprit sans aucun fait à la base. Or, dans mon livre, tout repose sur des faits et leurs conséquences immédiates. Comme je l'ai écrit plus haut, on ne répond à des faits que par d'autres faits. Mon travail ayant consisté à préciser l'œcologie du Saumon à l'aide d'observations minutieuses, il eût fallu effectuer d'autres observations, parallèles aux miennes, capables de fonder ensuite une discussion documentaire et scientifique. M. Menzies n'en a rien fait. Il n'a pas tenté de vérifier mes recherches en cherchant à son tour comment, dans le cas du Saumon et de sa migration, réagissent l'un sur l'autre le milieu intérieur de l'organisme et le milieu extérieur. Ayant établi par mes études qu'il existe là un déterminisme migrateur probable, je ne trouve dans sa notice rien qui y fasse allusion. S'il y a vue d'esprit, elle n'est guère de mon côté.

Sans insister davantage, je me borne, pour finir, à exprimer à mon tour un motif de désappointement. C'est à propos de l'une des phrases finales de la critique, faisant allusion à un désaccord avec Johs. Schmidt. Dans les trois chapitres que j'ai consacrés à l'Anguille, cette critique n'a trouvé à citer qu'une remarque sur l'âge des Civelles des Etats-Unis. Elle a délaissé tout le reste. Or, ces trois chapitres, qui composent une synthèse de la biologie de l'Anguille d'Europe telle qu'on doit l'établir actuellement, s'inspirent entièrement, et nominativement, des mémorables travaux du regretté Johs. Schmidt. J'avais avec lui, non seulement des rapports de savant à savant, mais aussi des relations familiales et affectueuses. Nous avons souvent causé ensemble de ses explorations. Ayant lu mon ouvrage dans l'édition française de 1929, il m'a répété à plusieurs reprises qu'il y avait trouvé le meilleur résumé des résultats qu'il avait obtenus. Or, rien ne paraît de ces chapitres, et de mon hommage à Schmidt, dans l'analyse rédigée par M. Menzies. C'est pour moi une impression des plus pénibles que de voir mes sentiments ainsi travestis.

Louis Roule,

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Reviews.

S. W. Brujewicz und **N. P. Karpova.** "Abhängigkeit des pH von der Temperatur in Pufferlösungen.". Biochem. Zeitschr. Bd. 251, Heft 1—3, S. 60—69. Berlin, 1932.

The investigations consist of electrometrical determinations of pH in some of the most important buffer solutions, viz., Palitzsch's borax-boric acid, Sörensen's phosphate and Mc Ilvaine's citrate phosphate solutions, the determinations being carried out at different temperatures, 0°, 18°, 25° C. This fulfils a long felt want with regard to determinations of pH with indicators mainly at low temperatures. However, in their work the authors have met with the same difficulties as earlier investigators, in that the standard value for the potential of a $^{n}/_{10}$ calomel-electrode against the normal hydrogen-electrode, which is requisite for the determinations, has hitherto not been reliably determined. They have in consequence had to content themselves with an extrapolated value, which, however, may be regarded as sufficient for the requirements of sea water research, for example. For the solutions of most importance as regards sea water research, viz., Palitzsch's borax-boric acid solutions, the authors have drawn up a table covering the temperatures 0—30° C. and pH 7.7—9.0 and showing the changes of pH with temperature (starting from 18°). A comparison with Walbum's earlier investigations of Sörensen's borate buffers between 10—30°, which have been accepted by Buch for the Palitsch solutions also, shows an agreement of 0.01 pH units.

Kurt Buch.

K. Kalle. "Phosphat und Gesamtphosphor in Beziehung zu Temperatur, Salzgehalt und Plankton an der Oberfläche der isländischen Küstengewässer." Ber. d. deutschen wiss. Komm. f. Meeresforschung. N. F., Bd. VI, Heft 4. Leipzig, 1933.

Since the coast of Iceland is bathed by the waters of the Gulf Stream on the south and west and by the cold, less saline waters of the East Greenland Current on the north and east, it provides a convenient place for the study of the effect of varied oceanographical conditions on the growth of plankton. With this object in view the German fisheries protection vessel «Weser" worked about thirty stations around Iceland in August and September 1932. Unfortunately owing to the absence of a suitable winch on board it was only possible to work surface stations. In the experience of the reviewer and others surface waters often contain much more phosphate, due apparently to decomposing floating matter, than does the water beneath. On such occasions surface figures taken alone are very misleading.

Inorganic phosphate commonly rose where glacier water entered the sea. Off the northeast corner of Iceland, in water of Arctic origin, a very close parallel was found between the rise and fall in inorganic and total phosphorus and the figures for total plankton obtained by Prof. Hentschel at the same time. To explain this unexpected result, Kalle suggests that very rich plankton populations contain many old individuals and as these die off they fall to the deeper waters and thus deplete the surface stock of total phosphorus. His results certainly support his contention that phosphorus in organic combination may afford a large reserve of nutrient material which is not taken into account when inorganic phosphate alone is determined. The amount of total phosphorus found around the coast of Iceland in water of oceanic character varied between 25 and 70 mg. P per cubic metre. In the summer of 1931 Ibañez (unpublished work) found a similar range in the surface water of the English Channel — between 25 and 55 mg. P per cubic metre. Any arsenite present will be recorded in the total phosphorus since after oxidation arsenate gives a similar colour reaction.

In the determination of total phosphorus the sample of water is first treated on the steam bath with acidified persulphate in order to oxidise organic matter. The excess of persulphate and free chlorine is then removed by sodium sulphite and the total phosphate set free determined by the usual molybdate reaction. At present this determination must be made spectrophotometrically. Owing to the effect on colour development of the added salts the test solution has to be divided into two parts, to one of which 10 mg. per cubic metre of phosphate-phosphorus is added. The amount of phosphorus originally present is then calculated from the colour increment. Work on this method is still in progress at Hamburg and when completed the oceanographer should have yet another valuable aid in his study of nutrition in the sea.

L. H. N. C.

K. Buch. "Hydrografisk-kemiska studier uti Petsamo-fjorden jämte angränsande delar av Barentshavet". Mit deutscher Zusammenfassung. Fennia 57, No. 4. Helsingfors, 1933.

In der vorliegenden Arbeit wird zum ersten Male die hydrographisch-chemische Aufnahme eines Fjordes des Nördlichen Eismeeres beschrieben. Zunächst wurden die morphologischen Verhältnisse des Fjordes erforscht; sie werden durch eine gemeinsam mit S. E. Stenij entworfene Tiefenkarte dargestellt. Die hydrographischen Ergebnisse werden an Hand eines Längsschnittes diskutiert, in den ausser Salzgehalt und Temperatur auch die Verteilung der Gesamtkohlensäure und des pH aufgenommen sind. Besondere Aufmerksamkeit wurde der Kohlensäure und den Plankton-Nährstoffen zugewendet. Wie im Sommer zu erwarten, war die Oberflächenschicht an Phosphaten und Nitraten verarmt, zumal da ein Austausch mit dem nährstoffreichen Tiefenwasser durch die starke Schichtung in Salzgehalt und Temperatur unterbunden wurde. Aus denselben Gründen besitzt das Oberflächenwasser ein recht hohes pH (8.2—8.3), dem ein Kohlensäuredruck von etwa $2.2 \cdot 10^{-4}$ atm. entspricht. Da der gleichzeitig bestimmte Kohlensäuredruck der Luft im Mittel $3.3 \cdot 10^{-4}$ atm. betrug, so muss während dieser Zeit starke Absorption von CO_2 durch das Wasser stattgefunden haben. Es sei angemerkt, dass Buch in den kontinentalen Luftmassen etwas höhere CO_2-Gehalte fand als in Luftmassen atlantisch-maritimer Herkunft.

Die Kieselsäure war im Fjord offenbar durch Landeinfluss angereichert:

An der Oberfläche waren im Mittel 500 mg. gegenüber 230 mg. Si/m.^{3} im Barentsmeer vorhanden, während in der Tiefe des Fjordes sogar Werte von über 1000 mg. beobachtet wurden. Die Titrationsalkalinität war beträchtlich durch den Kalkgehalt des Petsamoelvs beeinflusst, der Wasser von A = 0.54 Milliäq. Liter zuführt. Das Mischwasser des Fjordes besitzt infolgedessen eine Alkalinität, welche der Formel A = 0.54 + 0.096 · Cl gehorcht.

H. W.

M. P. Freundler et **M^{me} M. Guaisnet-Pilaud.** "Sur l'eau normale méditerranéenne 2^{e}Partie." Stat. Océanog. de Salammbô. Bull. No. 26. Paris, 1932.

Die Frage der Verwendung des im Arbeitsbereich der Internationalen Meeresforschung verwendeten Normalwassers auch für das Mittelmeer hat zu langwierigen und umfangreichen Diskussionen Veranlassung gegeben, über die im ersten Teil der vorliegenden Arbeit berichtet ist (Vergl. Ref. Journ. du Conseil, VII, S. 415 ff.). Von den Verfassern wurde schliesslich der von M. K n u d s e n stammende Vorschlag als der geeignetste angesehen, nach dem ein natürliches und auf das Kopenhagener, das primäre Normalwasser, bezogene Mittelmeerwasser von ungefähr 21 ‰ Cl als sekundäres Normalwasser benutzt werden sollte. Als geeignetstes natürliches Mittelmeerwasser wurde die im westlichen Mittelmeer in etwa 400 m. Tiefe mit einem sehr konstanten Salzgehalt auftretende Wasserschicht angesehen; diese Schicht wurde auch in bequemer Nähe der Station 13½ sm. WNW. von der Insel La Galite in 400 bis 500 m. Tiefe festgestellt mit einem Chlorgehalt von 21.23 ‰. Die weitere Frage, ob bei Benutzung dieses Normalwassers auch die Korrektionstafeln von K n u d s e n Verwendung finden könnèn, wurde von den Verfassern experimentell untersucht und auf Grund der gewonnenen Feststellungen verneint. Der Chlorgehalt verschiedener Mittelmeerwasser wurde nach drei verschiedenen Methoden bestimmt, nämlich gewichtsanalytisch nach der Volhard'schen Methode, titrimetrisch unter Benutzung des Kopenhagener Normalwassers und ebenfalls titrimetrisch unter Verwendung des Mittelmeerwassers genannten Ursprungs als sekundäres Normalwasser. Festgestellt wurde, dass die gewichtsanalytisch ermittelten Werte in allen Fällen kleiner waren als die titrimetrischen gewonnenen und zwar war der Unterschied der nach der ersten und zweiten Methode gewonnenen Ergebnisse meist grösser als 0.02 ‰, der nach der ersten und dritten Methode abgeleiteten Ergebnisse mit Werten zwischen 0.03 und 0.08 ‰ aber noch erheblich grösser. Dies führte die Verfasser auf den Gedanken, dass sich bei Verwendung einer Silbernitratlösung noch geringerer Konzentration als sie bei Benutzung des Kopenhagener Normalwassers erforderlich ist, eine befriedigende Übereinstimmung der gewichtsanalytisch und titrimetrisch gewonnenen Werte erzielen lassen müsste; sie fanden, dass bei Verwendung einer Silbernitratlösung von der Konzentration 35.725 gr. $AgNO_3$ pro Kilo Lösung die Differenz kleiner als — 0.02 ‰ ist, womit sie die von ihnen gestellte Bedingung als erfüllt ansahen; hierbei ist vorausgesetzt, dass bei einer Temperatur nahe 15° gearbeitet wird. Die Bestimmung der bei Durchführung der Titration bei abweichenden Temperaturen erforderlichen Korrektionen ist in Aussicht gestellt. Entsprechend dem Ergebnis kommen die Verfasser zu dem neuen Vorschlag, die genannte Silbernitratlösung als Ausgangslösung für die Salzgehaltsbestimmung von Mittelmeerwasser zu benutzen. Über die Prüfung des Titers sowie den Anschluss an das Kopenhagener Normalwasser sind keine Angaben gemacht.

Bruno Schulz.

Georg Wüst. "Das Bodenwasser und die Gliederung der Atlantischen Tiefsee". Wiss. Ergebn. d. Deutsch. Atlant. Exped. 1925—1927, herausgeg. von A. Defant, Band VI, Teil 1, Lief 1. Berlin und Leipzig, 1932.

The paper has for its chief subject one particular feature of Atlantic circulation, viz. the Antarctic bottom-current, from the course of which the author has furthermore drawn interesting conclusions with regard to the topography of the sea bottom. The investigation is restricted to depths exceeding 4000 metres.

Wide use is made of Helland-Hansen's important notion of "potential temperature", *i. e.*, the temperature which the water would assume when raised adiabatically to the surface. This quantity affords excellent means for following the motion of an individual body of water; for it remains practically constant (if mixing processes be excluded), whereas the actual temperature *in situ* alters according to the adiabatic law as soon as the motion of the water has a vertical component. Similar use is made of the salinity as well, although, owing to its narrow limits of variation, it necessarily plays a secondary role in the investigation.

The paper opens with a critical inventory of all observations on temperature and salinity of the bottom-water in the North and South Atlantic below the 4000 m. level. The author accepts as reliable 688 temperatures and 240 salinities, a considerable number of which are due to the "Meteor"-expedition.

The bottom-water in the deep parts of the Atlantic is, according to Wüst, formed by the mixing of different components, two of which ought to be particularly mentioned here, viz., an Antarctic deep-water with potential temperature — 0.5° and salinity 34.64 ‰ and a North Atlantic deep-water with pot. temp. 2.1° and sal. 34.92 ‰. The former should be produced in the autumn and winter as a result of surface cooling and freezing processes about the line of convergence near the border of the pack-ice region and should so far be a parallel to the deep-water of the Norwegian Sea explained by Nansen and Helland-Hansen. A still colder, Antarctic bottom-water is supposed to be produced in wintertime within the shallow, littoral parts of the Wedell Sea and other Antarctic bays, thence gliding down along the bottom into the deep Antarctic basin.

From the geographical distribution of the potential temperature of the bottom-water Dr. Wüst plainly proves the existence of a northward moving bottom-current, fed originally by Antarctic deep-water though on its way gradually mixed with the superposed, warmer species of deep-water. In the eastern trough — east of the Mid-Atlantic Ridge — this bottom-current is known to be stopped by the Walfish Ridge in 35° to 20° S. Lat.; but in the western trough its influence is made evident as far as 40° N. Lat. In a preliminary discussion of the temperature observations made during the expedition Böhnecke came to the conclusion that the Mid-Atlantic Ridge is interrupted at the Romanche deep so as to allow a communication between the waters on both sides of the ridge down to 4100 or 4400 m. below the surface. The conclusive investigation of the matter has now been beautifully carried out by Dr. Wüst. The "saddle-depth", down to which passage over the ridge is free, is estimated at something between 4500 and 4800 m., and the Antarctic bottom-current, sending here a branch into the eastern Atlantic trough, is shown to reach southwards right down to the Walfish Ridge and northwards as far as the latitude of Madeira.

From the potential temperatures in different levels along the axis of the

current other important conclusions are drawn with regard to the topography of the sea-bottom. The saddle-depths of several submarine ridges transverse to the bottom-current are estimated, and arguments are given for the existence of ridges which have not yet been sounded. The author thus arrives at a picture of the sea-bottom which is here and there of a schematical or hypothetical character, but which will nevertheless claim great attention. The author furthermore propounds a consistent nomenclature for the bottom features of the deeper parts of the Atlantic, mostly in accordance with principles laid down by Supan. Basins and ridges etc. are defined from a sound oceanographical point of view, and with few exceptions they are denoted by the names of adjacent geographical objects. The scheme seems to be convenient and clear. No place is given to the entirely artificial notion of "deeps" exceeding some conventional number of fathoms or metres.

Dynamical questions are incidentally touched upon. The present writer wishes to draw attention to some very interesting instances of the apparent influence of the earth's rotation on the inclination of the isodensal surfaces. On the other hand objection should be made to one particular point, the actual importance of which may justify a rather full exposition, since it is question of a principle which seems to have been hitherto generally accepted as correct or, at any rate, as allowable. From the amount of chlorine and the potential temperature Dr. Wüst calculates according to Knudsen's tables (further interpolated by Schumacher) the "potential density", *i. e.*, the density which the water would have after having been raised adiabatically to the surface. At first sight the vertical gradient of potential density would seem to be the proper basis for an estimate of the degree of stability of the water-layers. As a matter of fact it would be so in the case of the surface-layers but in greater depths generally not, because the compressibility of the water diminishes with increasing temperature and salinity. Two water-samples which are brought to the sea-surface and have there different salinities and different temperatures but equal densities, will always and everywhere have equal *potential* densities; but nevertheless, when they are lowered side by side to 1000 m. say, they will arrive there with different densities, the colder and less saline water being now the heavier of the two. Whether the relative position of two adjacent water-layers is stable or unstable will obviously depend on the difference between the densities which the water-layers would assume when carried into one common level; but this common level must be chosen intermediate between the actual levels of the layers and not on the sea-surface.

Now Dr. Wüst finds, in the western Atlantic trough, a bottom-water covered by layers of *greater* potential density, a result which he seems to reject as inconsistent with dynamical laws. As a probable explanation of the apparent inconsistency he refers to the observation of Norwegian oceanographers that the bottom-water may continually dissolve lime, and that for this and other reasons the usual calculation of the density from the amount of chlorine may give slightly inaccurate results depending on the origin of the water-samples. The present writer has no ground for denying the possible truth of this latter statement, especially as it is said to be confirmed by analysis actually being carried out; but he wishes to emphasize that it is not necessarily demanded for *dynamical* reasons.

For the purpose of illustration we will consider "Meteor" Station 200 situated in the western Atlantic trough in 10° S. Lat. The conditions at the station are seen from the table below, the columns of which contain: 1st. col., standard depths in metres; 2nd and 3rd cols., the corresponding potential temperatures and salinities as given in Beilage V of Dr. Wüst's

paper; 4th col., the values of σ_0 calculated from the salinities by means of the formula given in Knudsen's tables; 5th and 6th cols., the temperatures t_4 and t_5 which a water sample would assume when carried adiabatically from its original level to the depths of 4000 and 5000 m. respectively; 7th col., the value $\sigma_{t,0}$ indicative of the "potential density" $1 + 0.001\ \sigma_{t,0}$; 8th and 9th cols., the values $\sigma_{t,4}$ and $\sigma_{t,5}$ similarly indicative of the densities which a water sample would assume when moved adiabatically to the depths of 4000 m. and 5000 m. respectively. Columns 5 and 6 are calculated by means of Tab. I in Ann. d. Hydr. usw. 1914, S. 342 and cols. 7, 8 and 9 by means of Tab. VI, a and b in "Tables for Sea-Water under Pressure", Publ. de Circ. No. 49. The values of σ_0, $\sigma_{t,0}$, $\sigma_{t,4}$ and $\sigma_{t,5}$ are calculated to 3 decimal places, but the last figure should be regarded as approximate only.

Metres	t_0	S	σ_0	t_4	t_5	$\sigma_{t,0}$	$\sigma_{t,4}$	$\sigma_{t,5}$
3500	2.27	34.92	28.063	2.63	2.76	27.908	45.888	50.122
4000	1.42	.83	27.989	1.76	1.88	.901	.974	.231
4500	0.59	.76	.933	0.90	1.02	.900	46.069	.344
5000	0.31	.72	.900	0.61	0.73	.884	.085	.368
5600	— 0.1	.68	.868	0.19	0.30	.873	.124	.418

The 7th column shows, in accordance with Dr. Wüst's observation, that the potential density decreases from 3500 m. downwards. Or in other words: if two quantities of water from different levels were raised side by side to the surface, the water which came from the lesser depth would have a tendency to sink below the originally deeper water, so that the layers would turn upside down. The 8th column shows that conditions would be reversed if the two quantities of water were lowered 4000 m. below the surface, so that in this level they would have the tendency to resume their original mutual positions. The same result is still more pronounced if the two quantities of water be assumed to meet in a still greater depth, 5000 m., say (9th col.); and, in conclusion, the water-layers at the station in question are decidedly stable, even on the assumption that the real potential densities are equal to the calculated ones.

Adopting the idea of Helland-Hansen the author finds a remarkably close relationship between salinity and potential temperature of the bottom water, especially when the western and the eastern troughs are considered separately. The fact is made use of for drawing greatly interesting conclusions as to the percentage of Antarctic and North Atlantic water in the bottom-current in various latitudes. It is found to alter comparatively slowly during the passage through the deeper basins but rapidly, owing to increased mixing, when the current passes over a cross-ridge.

The paper contains other interesting investigations. A surprisingly pronounced stratification of the bottom-water — in contradistinction to the homogeneous bulk of deep-water — is found and made the subject of a particular study. The possible influence of the current on the content of lime in the bottom-water and in the bottom-deposits is investigated. Within the narrow compass of printed pages Dr. Wüst's paper exhibits ideas and actual knowledge which may greatly promote our comprehension of the Atlantic circulation.

V. W. Ekman.

A. E. Parr. "A Geographic Ecologial Analysis of the Seasonal Changes in Temperature Conditions in Shallow Water along the Atlantic Coast of the United States". Bingham Oceanographic Collection. Yale University. Vol. IV, Art. 3, pp. 90. New Haven, Conn., 1933.

The analysis of daily surface temperatures received from lightships and lighthouses has seldom yielded important conclusions from the point of view of physical oceanography. However, in this paper Parr has demonstrated that such material can be extremely illuminating when studied from the standpoint of the biologist.

The records kept at 19 stations scattered along the whole eastern coast of the United States over a three-year period (1928—30) as well as the temperature curves of Rathbun (1881—85) for similar stations are presented in a form which clearly brings out the seasonal variations in the shallow-water zone along this 1400 mile stretch of coastline. The winter and summer temperatures (in degrees Fahrenheit) at seven representative localities can be tabulated as follows:

	Febr.	Aug.
Thatchers Island, off Gloucester, Mass.	36°	62°
Nantucket Lightship, off Nantucket Shoals	37°	58°
Fire Island Lightship, off New York	38°	68°
Winter Quarter Lightship, off Virginia	41°	72°
Diamond Shoal Lightship, off Cape Hatteras	62°	80°
Rattlesnake Shoal Lightship, off Charleston, South Carolina	52°	80°
St. John River Lightship, off Jacksonville, Florida	58°	81°

This data shows that a warm-water temperature barrier is established in the region of Cape Hatteras during the winter, while a cold barrier develops in the region of Cape Cod-Nantucket Shoals during the summer months; but in neither locality do these temperature barriers last through the whole year. The observations are found to explain both the period, extent and character of the seasonal invasions of the middle Atlantic coastal waters by fish populations of northern or southern origin. The ecological relationships between adjacent homothermal and heterothermal areas are considered and an explanation offered why the winter invasion of the middle Atlantic region from the north should be quantitatively poor, why the seasonal changes of the fish fauna of this region should be so complete, and why summer fish should be expected to concentrate near Cape Hatteras in winter. Suitable terms for the six main types of seasonal temperature curves are presented and the biological meanings of the various ways in which the shallow water temperatures can fluctuate are discussed.

These and other interesting conclusions which Parr draws from this very large collection of surface temperatures of course only apply to the shallow-water zone where, through tidal turbulence and wind stirring, the water is usually homogeneous from surface to bottom. The author points out that along the eastern shore of the United States the area inside the 10-fathom curve (not including the semi-inclosed bays and sounds) is some 1100 square miles in extent. Especially between Chesapeake Bay and New York, this shallow band is exceptionally broad and is a region providing an extensive fishery.

The question naturally arises whether or not surface observations in this band give the approximate temperature of the whole water column. On the whole, Parr's argument concerning the lack of stability between the 10-fathom curve and the shore seems justified, though supported only by subsurface observations in the Gulf of Maine. It seems probable that during

most of the year this inshore band is well mixed from surface to bottom and especially at the critical points off headlands and capes where the observations were usually made. However, the author had no data at his disposal to account for one important factor in his consideration of the question of stability. The inshore shallow band, especially in early spring, receives a considerable supply of fresh water from rivers. Thus the stability may at times become very marked due to the sudden increase in the amount of river water flowing southward along the shore. It seems questionable at such times whether, along a straight stretch of coastline, surface readings will always be indicative of the temperature, even at such slight depths as 10 fathoms. Only through a considerable number of subsurface temperature and salinity observations along the band of shallow water can this point be cleared up, and until they are available, we can accept P a r r's surface temperature diagrams as showing closely the thermal conditions down to 10 fathoms along this great stretch of coast line.

C. I.

Takaharu Nomitsu. "A Theory of the Rising Stage of Drift Current in the Ocean. I. The Case of No Bottom-Current; II. The Case of No Bottom-Friction". Mem. Coll. Sci., Kyoto Imp. Univ. Ser. A. Vol. XVI, Nos 2 & 4. Kyoto, 1933.

Der Verfasser entwickelt eine neue Methode zur theoretischen Bestimmung des Triftstromes bei plötzlich beginnendem oder aufhörendem Wind unter der Annahme eines endlosen Meeres mit konstanter Tiefe. Für unendliche Tiefe hat F r e d h o l m früher eine Lösung gegeben, und kürzlich hat F j e l d s t a d Methoden zur Behandlung des Problems der Entstehung der Triftströme in Meeren mit endlicher Tiefe entwickelt. Die neue Methode von T a k a h a r u N o m i t s u ist verhältnismässig einfach und übersichtlich. Die Theorie gibt eine sehr klare Darstellung sowohl von der Zunahme des Stromes bei beginnendem Wind wie von der Abnahme des Stromes bei aufhörendem Wind. In Teil I wird das Problem unter der Voraussetzung, dass die Stromgeschwindigkeit am Boden Null ist, behandelt, in Teil II wird dasselbe Problem unter der Annahme von vollständiger Gleitung über den Boden (keine Bodenreibung) diskutiert und für konstante Reibungskoeffizienten gelöst. Von den Ergebnissen seien folgende erwähnt:

1) Bei plötzlich beginnendem (oder aufhörendem) Wind vollführt der Strom eine Art von Schwingungen um seine endliche Grösse und Richtung mit einer Periode von 12 Pendelstunden. Unter der Annahme, dass kein Bodenstrom besteht, erreicht der winderzeugte Strom seinen schliesslichen Wert (entsprechend dem stationären Triftstrom von E k m a n) nach dem Verlauf einer Zeit, die von der sog. Reibungstiefe D und der Meerestiefe abhängt, und zwar ungefähr nach folgenden Zeiten:

Meerestiefe:	D/10	D/4	D/2	D	2D
Zeit in Pendelstunden:	1	6	18	48	120

2) Im Falle, wo keine Bodenreibung besteht erreicht der Strom niemals den stationären Wert, sondern schwingt mit der gleichen Periode von 12 Pendelstunden um diesen Wert, und zwar so, dass der Hodograph einen asymptotischen Kreis hat, dessen Radius umgekehrt proportional zur Meerestiefe ist. Bei unendlicher Tiefe erhält man somit die gleiche Lösung wie im Falle 1.

3) Unter der Annahme, dass kein Bodenstrom besteht, wächst sowohl die Ablenkung wie die Geschwindigkeit des Triftstromes bei abnehmender

Meerestiefe. Die Verhältnisse sind somit in dieser Hinsicht entgegengesetzt den Verhältnissen bei Berücksichtigung der Bodenreibung.

Nach der Ansicht des Verfassers können die obigen zwei Spezialfälle von Bedeutung sein, wenn man auch annehmen muss, dass die wirklichen Verhältnisse in den Meeren zwischen diesen beiden extremen Annahmen liegen. Im Anschluss an den Fall mit konstantem Wind behandelt der Verfasser schliesslich auch den Fall mit variablem Wind, wo der Wind eine gegebene Funktion der Zeit ist. Hierbei benutzt er ein Theorem, das in anderem Zusammenhang veröffentlicht wird. Offenbar hat man in Zukunft weitere Entwicklung der Theorie zu erwarten, und zwar besonders unter näherer Berücksichtigung der wirklichen Reibungsverhältnisse in den Meeren. *E. P.*

Takaharu Nomitsu. "On the Development of the Slope Current and the Barometric Current in the Ocean. I. The Case of No Bottom-Current". Mem. Coll. Sci., Kyoto Imp. Univ. Ser. A, Vol. XVI, No. 3. Kyoto, 1933.

Eine ähnliche Methode wie die oben besprochene für den Triftstrom wird vom Verfasser auch zur Untersuchung des Staustromes entwickelt. Bei einer plötzlich entstandenen Neigung der Meeresoberfläche entsteht ein Staustrom, der unter den angenommenen Voraussetzungen inbetreff der Reibung asymptotisch um seine endliche Grösse und Richtung schwingt. Der Strom erreicht seinen schliesslichen Wert unter den gleichen Voraussetzungen in derselben Zeit wie der Triftstrom. Ganz kurz diskutiert der Verfasser schliesslich die von einem horizontalen Luftdruckgradienten über einem Ozean verursachte Strömung (barometric current) und äussert die Meinung, dass diese in den Weltmeeren von grösserer Bedeutung sein dürfte als im allgemeinen bisher angenommen worden ist.

E. P.

Takaharu Nomitsu. "On the Density Current in the Ocean. I. The Case of No Bottom-Current." Mem. Coll. Sci., Kyoto Imp. Univ. Ser. A, Vol. XVI, No. 4. Kyoto, 1933.

Der Verfasser definiert als Dichtestrom (density current) diejenige Strömung, die von einer lokalen Dichtedifferenz im Meere ohne Berücksichtigung einer Neigung der Meeresoberfläche verursacht wird, während der Konvektionsstrom dagegen von sowohl einem Dichtestrom als auch einem Staustrom zusammengesetzt ist. Die Behandlung des reinen Dichtestromes geschieht ganz analog wie die oben referierte Behandlung des Triftstromes und Staustromes. Beim Staustrom ist der Gradient im Wasser durch die Neigung der Meeresoberfläche bestimmt, beim Dichtestrom ist der Gradient in jedem Niveau eine Funktion des horizontalen Dichtegradienten. Da grössere Dichtegradienten nicht schnell entstehen können, wird eine Theorie der Entwicklung des Dichtestromes bei einem plötzlich entstandenen Solenoidfeld von nur geringer praktischer Bedeutung.

Unter Berücksichtigung der Begrenzungen der Meeresgebiete entwickelt sich aus einer reinen Dichteströmung allmählich eine kombinierte Dichte- und Stauströmung, die gewöhnlich Konvektionsströmung genannt wird. In der Arbeit von T a k a h a r u N o m i t s u werden verschiedene Typen solcher Konvektionsströme theoretisch untersucht, und zwar im Anschluss an die speziellen von E k m a n behandelten Typen. Die Theorie des Verfassers leitet zu Ergebnissen, die in gewissen Punkten von den E k m a nschen Resultaten abweichen. U. a. findet der Verfasser, dass

das Niveau der Nullströmung nicht im allgemeinen mit dem Niveau, wo die isobaren Flächen horizontal verlaufen, identisch ist.

Da die Ergebnisse natürlich sehr eng mit den angenommenen Voraussetzungen zusammenhängen, und da besonders bei kräftiger Schichtung im Ozean die Annahme eines konstanten Koeffizienten der Turbulenzreibung wohl kaum aufrecht erhalten werden kann, wäre es sehr interessant, empirische Bestätigungen der theoretischen Ergebnisse zu erhalten, wie auch weitere Annäherungen an die tatsächlichen Verhältnisse vorzunehmen.

E. P.

V. W. Ekman. "Studien zur Dynamik der Meeresströmungen". Gerlands Beitr. z. Geophysik, Bd. XXXVI, S. 385—438. Leipzig, 1932.

Mit dieser Arbeit ist, so darf man wohl sagen, die E k m a n'sche Theorie in eine dritte Stufe der Entwicklung eingetreten. Die älteste Theorie (1902, 1905, elementar dargestellt 1906 in Ann. d. Hydr.) rügte an den früheren Anschauungen die Vernachlässigung von Turbulenz und ablenkender Kraft der Erdrotation und gipfelte in einer Gliederung der Ströme in drei Stockwerke: Von oben reichte bis zur "oberen Reibungstiefe" D′ der unmittelbare Einfluss des Windes durch die Turbulenz (Oberstrom), und vom Meeresboden bis zur unteren Reibungstiefe (D″ über dem Boden— Bodenstrom) die Bremswirkung der Bodenhindernisse. Dazwischen aber floss, praktisch nicht beeinflusst von Reibung, ein homogener Tiefenstrom, der wegen seiner Mächtigkeit für die Verfrachtung des Wassers von grosser Bedeutung ist, und auf dessen Untersuchung sich daher die weitere Entwicklung der Theorie konzentrierte. Eine wichtige Voraussetzung der ältesten Theorie war die eines konstanten Windes, konstanter Meerestiefe und konstanter geographischer Breite. Das erwähnte Stromsystem konnte deshalb zunächst jedesmal nur für verhältnismässig kleine Gebiete gelten ("Elementarstrom"), und die zweite Entwicklungsstufe der Theorie war infolgedessen durch die Frage gegeben, was insbesondere aus dem Tiefenstrome wird, wenn die obigen drei Voraussetzungen aufgegeben werden: "ältere Theorie" (1923, von E k m a n in diesen Blättern dargestellt, Bd III, 1928, S. 295—327). Die Antwort ging dahin, dass entsprechend den Ungleichmässigkeiten des Windes, der Meerestiefe und der geographischen Breite anemogene, topographische und planetarische Wirbelwirkungen auftreten, die im Tiefenstrome Wirbel und Zerrungen auslösen, welche unter der Bezeichnung "Quasiwirbel" zusammengefasst werden können, und welche so beträchtlich sind, dass sie dem Tiefenstrome in vielen Fällen keinen Raum zur Entwicklung lassen.

Die neue Theorie geht wiederum einen Schritt weiter, indem sie auch Beschleunigungen zulässt; solche können auch bei stationären Strömen, und von anderen ist keine Rede, vorkommen, weil Wasserteilchen bei ihrer Bewegung an Orte mit anderer Geschwindigkeit gelangen, also ihren Bewegungszustand ändern. Zu dem Quasiwirbel kommt infolgedessen eine Wirbelbeschleunigung hinzu, und dadurch wird die mathematische Aufgabe so verwickelt, dass vollständige Lösungen kaum mehr möglich sind. Es ergibt sich, dass die Wirbelwirkung einmal etwas herabgesetzt wird, andrerseits aber sich örtlich verlagert, indem z. B. für die topographische Wirbelwirkung nicht mehr der Böschungswinkel des Bodens allein den Ausschlag gibt, sondern auch die Lage der tiefsten (oder höchsten) Stelle des Grundes und das Verhältnis des Tiefenunterschieds zur Gesamttiefe von Bedeutung ist. Ferner lassen sich topographische und planetarische Wirkung nicht mehr völlig von einander trennen, sondern sind mit einander verkoppelt. Der Abschwächung der Wirbelwirkung durch Hinzutreten der Beschleunigung

steht andrerseits gegenüber eine Verstärkung, dadurch, dass der Koeffizient der Scheinreibung nicht, wie früher der Einfachheit halber angenommen, konstant, sondern am Boden kleiner als weiter oben ist; um dieser Tatsache gerecht zu werden, nimmt die neue Theorie in Anlehnung an eine Vorstellung G. I. Taylors und eine ältere Vermutung Ekmans eine besondere Gleitschicht am Boden an.

Ausser den Beschleunigungen und ausser der Veränderlichkeit des Reibungskoeffizienten werden endlich auch die senkrechten Komponenten sowohl der Ablenkungskraft, als auch des Stroms selbst berücksichtigt; doch stellt sich die erstere mit Sicherheit, die letztere wahrscheinlich als belanglos heraus. Zusammenfassend kann man von der "neuen Theorie" daher sagen, dass zwar die Aufgabe zu verwickelt wird, um vollständige Lösungen zuzulassen, dass aber die Hindernisse, welche die Kugelgestalt der Erde und die Bodenformen einer Ausbildung kräftiger Tiefenströme entgegenstellen, auch unter den Voraussetzungen der neuen Theorie noch in den meisten Fällen zu ihrer Zerstörung ausreichen dürften.

H. Thorade.

I. **T. Gaarder** und **R. Spärck.** "Hydrographisch-biochemische Untersuchungen in norwegischen Austern-Pollen." Bergens Museums Årbok 1932, Naturvidenskapelig rekke Nr. 1. Bergen, 1932.

II. **T. Gaarder.** Untersuchungen über Produktions- und Lebensbedingungen in norwegischen Austern-Pollen. Ibid., Naturvidenskapelig rekke Nr. 3. Bergen, 1933.

Die eigenartigen hydrographischen Verhältnisse der norwegischen Austernpollen sind durch die Arbeiten von Helland-Hansen in ihren Hauptzügen bekannt geworden. Neuerdings sind durch das Zoophysiologische Institut in Kopenhagen und das Museum in Bergen wieder eingehende Untersuchungen der biochemischen und produktionsbiologischen Verhältnisse dieser Gewässer aufgenommen worden mit dem Ziele, die Faktoren nachzuweisen, welche die von Jahr zu Jahr schwankenden Erträge der Austernpolle bedingen. Diese Untersuchungen, über deren Ergebnisse noch weitere Veröffentlichungen zu erwarten sind, dürfen allgemeines Interesse beanspruchen, da sie an dem Beispiele eines abgeschlossenen Salzwassersees sehr lehrreiche Aufschlüsse geben über die Zustandsänderungen des Wassers unter dem Einflusse der meteorologischen Verhältnisse und deren Auswirkungen auf das Mikroplankton und auf die sich davon ernährenden Zooplanktonten.

I. In der erstgenannten Arbeit wird zunächst eine Lagebeschreibung des Espevik-Polles und des Sælö-Polles gegeben, in denen während der Sommermonate der Jahre 1927 bis 1929 Beobachtungen angestellt wurden. Dies sind kleine Salzwasserbecken von 200—300 m. Durchmesser und 4—5 m. Wassertiefe, durch eine Felsbarre vom offenen Fjord abgetrennt, mit dem sie durch einen Kanal in Verbindung stehen. Dieser wird im Sommer geschlossen, und über dem im Poll abgesperrten Meerwasser schichtet sich nun das durch Niederschläge und Rinnsale zugeführte Süsswasser, eine Oberflächenschicht von Brackwasser bildend. Sie wirkt wie die Glasfenster eines Treibhauses, indem sie die Sonnenstrahlen in das darunter liegende Salzwasser eintreten lässt, das sich dadurch erwärmt, schützt es jedoch während der Nacht vor Wärmeverlust. So werden Temperaturen von 30° und mehr erreicht, die für diese Breitengrade ganz aussergewöhnlich sind.

Der Espevik-Poll ist seit 1882 ununterbrochen in Betrieb; in ihm werden in guten Jahren ½ bis 1 Million Jungaustern gewonnen. Ihm galt deshalb vornehmlich das Interesse der Untersucher. Alle drei Tage etwa wurden

an einer bestimmten Stelle des Polles Serienbeobachtungen angestellt über Temperatur, Salzgehalt, Sauerstoff, pH, Kalk, Phosphat, Nitrat, Oxydierbarkeit und Planktongehalt. Bei der Untersuchung des Planktons wurde besonderes Gewicht gelegt auf des Vorkommen von Austernlarven und deren Nahrungskonkurrenten und auf die Mikroorganismen der Grössenordnung 1—3 μ, die für jene als Nahrung in Betracht kommen. Zur Ergänzung wurden 1927 Kontrollbeobachtungen im freien Fjordwasser und 1929 Paralleluntersuchungen im nahen Sælö-Poll vorgenommen. Die Ergebnisse der während der drei Jahre ausgeführten Beobachtungen und Analysen sind in Tabellen zusammengestellt und werden ausführlich an Hand von 65 graphischen Darstellungen besprochen.

Im Sommer der Jahre 1927 und 1929 wechselten kürzere Perioden mit relativ reichen Niederschlägen und längere Perioden mit heiterem Wetter und starker Sonnenstrahlung. Im Jahre 1928 dagegen herrschte fast dauernd kühles, trübes und regnerisches Wetter. Diese Unterschiede prägten sich deutlich im physikalisch-chemischen Zustande des Pollwassers aus. Die folgenden Zahlen geben eine Vorstellung über die Intensität der Stoffwechselvorgänge in dem unter der brackigen Deckschicht liegenden Salzwasser; sie stellen die in 1—2 m. Tiefe Ende Juli bis Anfang August beobachteten Maximalwerte dar.

Jahr	Temperatur	Sauerstoff-Gehalt	pH
1927	28.0°	12.4 cm.³/l. (250%)	8.9
1928	23.4°	6.9 „ (120%)	8.3
1929	26.9°	12.7 „ (256%)	8.8

Die Zustände in den Jahren 1927 und 1929 waren also einander ähnlich, während 1928 wesentlich abwich, ganz in Übereinstimmung mit den meteorologischen Verhältnissen der betreffenden Jahre. Niederschläge und Sonnenbestrahlung beeinflussen also stark die Produktionsvorgänge im Poll. Hat sich im Frühjahr durch reichliche Niederschläge eine Brackwasserschicht gebildet und bringt der Sommer viel Sonnenschein, so erreicht das Wasser unterhalb der Sprungschicht hohe Temperaturen (so 1927 und 1929). Die Assimilationstätigkeit des Phytoplanktons ist sehr rege, dass Wasser reichert sich stark mit Sauerstoff an, und der pH-Wert steigt infolge des CO_2-Verbrauches. In trüben, regenreichen Sommern (wie 1928) ist mangels ausreichender Lichtzufuhr die Assimilation gering, die Temperatur geht wenig über 20° hinaus, und Assimilations- und Dissimilationsvorgänge halten einander die Waage, so dass Sauerstoff und pH keine wesentliche Steigerung erfahren.

Die vom Bodenschlamm ausgehenden Fäulnisvorgänge wirken sich umso mehr nach oben aus, je geringer die Sonneneinstrahlung ist. In 4 m. Tiefe fanden sich 1927 noch 7.6 cm.³/l. Sauerstoff; die Lichtverhältnisse waren damals so günstig, dass das Sauerstoff-Maximum erst in 3 m. Tiefe lag und bei 4 m. noch ein ziemlich reges Planktonleben herrschte. In dem weniger günstigen Sommer 1929 befand sich das Sauerstoff-Maximum höher, in 1—2 m., während in 4 m. Tiefe der Sauerstoff bis auf 0.1 cm.³/l. verbraucht war. Im sonnenarmen Sommer 1928 kam es überhaupt nicht zu einer wesentlichen Übersättigung des Wassers mit Sauerstoff und zur Ausbildung eines ausgeprägten Maximums unter der Brackwasserschicht, und in 4 m. Tiefe fehlte der Sauerstoff vollständig; hier wurden vielmehr 1.24 cm.³/l. Schwefelwasserstoff festgestellt.

In Übereinstimmung mit der Verteilung des Sauerstoffes zeigen auch die Reaktionsverhältnisse des Wassers im Espevik-Poll, dass der Zustand

im Juli 1929 eine Zwischenstufe darstellte zwischen demjenigen von 1927 und dem von 1928. Im Sommer 1927 erreichte die intermediäre Maximumschicht mit pH >8.7 ihre grösste vertikale Ausbreitung von 1—3 m. Tiefe. 1929 lag diese Schicht nur in 0.75—1.5 m. 1928 dagegen wurden so hohe Werte nie erreicht, als Maximum wurde in 1—2 m. Tiefe nur pH 8.2—8.3 gemessen. In den tieferen Wasserschichten bis 4 m. hinab ging das pH im Juli 1927 nie unter 8.5; 1929 sank es unter 8, im Juli 1929 sogar bis auf 7.4.

In der oberflächlichen Brackwasserschicht werden die Schwankungen des pH von der Niederschlagsmenge bestimmt; hier wurde eine ausgesprochene Parallelität zwischen pH und Salzgehalt gefunden. Der Sauerstoffgehalt dieser Schicht war in allen drei Beobachtungsjahren der gleiche und nahe am Sättigungswert, da hier die Atmosphäre ausgleichend wirkt.

Der Gehalt des Pollwassers an Phosphat und Nitrat erwies sich als sehr gering. Von dem umgebenden Waldboden werden durch das Regenwasser kleine Mengen dem Poll zugeführt, die gelegentlich in der brackigen Oberflächenschicht nachgewiesen werden konnten. Bei günstigen Lichtverhältnissen, wie im Jahre 1927, werden sie jedoch durch das Phytoplankton rasch aufgebraucht. In den meisten Fällen konnte nur festgestellt werden, dass die Menge des im Pollwasser enthaltenen Phospates und Nitrates unterhalb der Genauigkeit der angewendeten Methoden lag (< 3 mg. N und 8 mg. P_2O_5/m.^{3}). Die Bestimmungen waren häufig durch gelbliche Farbe und Trübung des Wassers sehr erschwert. In Sommer 1928 wurden in 2—4 m. öfters Mengen von 10—57 mg./m.^{3} P_2O_5 gefunden. Diese Anreicherung an Phosphat, das aus der Zersetzung organischer Stoffe stammte, war eine Folge der schlechten Lichtverhältnisse dieses Jahres, welche die Assimilationstätigkeit des Phytoplanktons herabsetzte.

Die Süsswasserrinnsale führen dem Poll auch beträchtliche Mengen organischer Stoffe zu. Als Mass dafür wurde der Kaliumpermanganatverbrauch des Wassers benutzt. Während das tiefere, stark salzhaltige Poll-Wasser eine Oxydierbarkeit von 30—40 cm.^{3}/l. 0.01 n. $KMnO_4$ aufwies, die etwa dem im Wasser des offenen Fjordes gefundenen Wert entspricht, wurden an der Oberfläche stark schwankende Werte beobachtet, so einmal im Jahre 1927 als Maximum 166 bei einem Salzgehalt von 7‰. In 1—3 m. Tiefe herrschte im allgemeinen eine gewisse Übereinstimmung zwischen den Schwankungen der Oxydierbarkeit und denen des gelösten Sauerstoffes in der Weise, dass ein langsames Abnehmen der Oxydierbarkeit von einer anhaltenden Steigerung der Sauerstoffmenge begleitet wurde. In den kühlen und regnerischen Sommermonaten des Jahres 1928 wurden bei weitem keine so hohen Maximalwerte in der Oberflächenschicht gefunden, offensichtlich deshalb, weil im Waldboden die Spaltung der organischen Stoffe träger und weniger vollständig vor sich ging als in dem warmen Sommer 1927.

Über die Ergebnisse der biologischen Untersuchungen, die sich auf die quantitative Bestimmung der Bakterienflora und des Phyto- und Zooplanktons erstreckten, werden die Verfasser in einer späteren Arbeit ausführlich berichten. In der vorliegenden Veröffentlichung sind nur einige zusammenfassende Angaben darüber gemacht. In vollkommener Parallele zu den hydrographischen Verhältnissen zeigte auch die Zusammensetzung des Planktons, sowohl quantitativ wie qualitativ, eine grosse Übereinstimmung in den Jahren 1927 und 1929, während 1928 stark abweichende Resultate brachte.

In dem kühlen, sonnenarmen Sommer 1928 war das Plankton charakterisiert durch eine reiche Bakterien- und Peridineenflora, also saprophytisch lebende Organismen. Diesen gegenüber traten kohlensäureassimilierende

einzellige grüne und blaugrüne Algen von 2—3 μ Grösse zurück. In den warmen und sonnenreichen Jahren 1927 und 1929 lagen die Verhältnisse gerade umgekehrt; das autotrophe Mikroplankton herrschte vor, die Zahl der Bakterien war gering, und die Peridineen fehlten gelegentlich fast ganz. Aus der wechselnden Häufigkeit des Metazoenplanktons, insbesondere der Larven von Schnecken, Austern und anderen Muscheln, darf man schliessen, dass Bakterien und Peridineen als Nahrung wenig geeignet sind; für sein Gedeihen bedarf es der kohlensäureassimilierenden Algen. 1927 und 1929 waren die im Poll lagernden Brutaustern in gutem Ernährungszustande, und es fand ergiebiges Laichen und guter Brutansatz statt. 1928 dagegen war die Beschaffenheit der Mutteraustern schlecht und die Sterblichkeit sehr gross. Das Laichen blieb vollständig aus, obwohl die Wassertemperatur sich im Juli und August über 20° hielt.

Die Träger der Nahrungsproduktion im Poll sind also jene 2—3 μ grossen grünen und blaugrünen Algen, und die Lichtzufuhr ist der entscheidende Faktor, von dem ihr Gedeihen abhängig ist.

II. DieseVeröffentlichung schliesst sich an die zuvor besprochene Arbeit von Gaarder und Spärck an. Im Sommer 1931 wurden im Espevik-Poll und im Sælö-Poll vergleichende Beobachtungen angestellt insbesondere über die Anforderungen, welche die als Träger der Produktion erkannten kleinen grünen und blaugrünen Planktonalgen an ihre Umgebung stellen. Während der Espevik-Poll sich selbst überlassen blieb, wurden dem Wasser des Sælö-Polles Nitrat und Phosphat zugeführt (im ganzen 0.2 mg. N und 0.15 mg. P pro l.). In beiden Pollen waren die gewöhnlichen charakteristischen Verhältnisse zu beobachten; im Espevik-Poll betrug die Dicke der Brackwasserschicht 1 m., im Sælö-Poll ½ m.; darunter lagerte Wasser von 24—29 ‰ Salzgehalt. Das in 1—2 m. befindliche intermediäre Temperaturmaximum erreichte Werte von 25—26°, obwohl in der Beobachtungszeit im Juli nur wenig Sonnenschein herrschte. Sauerstoffgehalt und Wasserstoffionenkonzentration der produktiven Wasserschichten beider Polle zeigten bemerkenswerte Unterschiede. Im ungedüngten Espevik-Poll wurden in 1—3 m. 8.5—10.9 cm.³/l. Sauerstoff und pH 8.6—8.7 gefunden. Im gedüngten Wasser des Sælö-Polles hatte sich das Sauerstoff-Maximum bereits in 0.5 m. Tiefe ausgebildet; hier wurden 13.6 cm.³/l. O_2 festgestellt, in 3 m. noch 10.5 cm.³/l. Die pH-Werte lagen dementsprechend hoch bei 9.1 bzw. 8.6. Die Nährsalzzugabe hatte also die Assimilationstätigkeit des Phytoplanktons stark gefördert, und damit waren auch die Nahrungsverhältnisse wesentlich gebessert. Im Sælö-Poll wurden Mitte Juli in 10 l. Wasser aus 1—2 m. Tiefe 80—500 Muschellarven, 300—1400 Schneckenlarven und 10—40 Austernlarven gezählt. Im Espevik-Poll betrug die Zahl der Molluskenlarven im Höchstfalle nur wenige Hundert; Austernlarven wurden in relativ grösserer Menge festgestellt (28—210), sie wuchsen jedoch nicht, und erst der sonnige Spätsommer brachte einen reichen Brutansatz von ¾ Million Jungaustern, die zu Beginn des Winters noch sehr klein waren und sämtlich infolge Unterernährung zugrunde gingen. Im gedüngten Wasser des Sælö-Polles dagegen fand im Juli und im Spätsommer Brutansatz statt (ca. 150,000 Stück), der den Winter gut überstand.

Als Sauerstoffproduzenten im Poll kommen in der Hauptsache zwei verschiedene Formen einer einzelligen Alge in Betracht. Die eine ist 1—2 μ gross, ellipsoid und blaugrün und ist am häufigsten unterhalb der Brackwasserschicht in 1—3 m. Tiefe. Die andere Form ist 3 μ gross, mehr kugelförmig und grün; sie findet sich vornehmlich in den obersten Wasserschichten. Die blaugrünen Algen wurden im (gedüngten) Sælö-Poll

in 1.5—2 m. Tiefe in der ausserordentlich grossen Zahl von 155 pro mm.^{3} gefunden; im Espevik-Poll zählte man maximal nur 43 Stück. Die grünen Algen waren weniger häufig; davon wurden in der Brackwasserschicht des letztgenannten Polles 10—20 festgestellt, im Sælö-Poll nur 1 pro mm.^{3}.

In einer Reihe von Kulturversuchen wurden die Lebensforderungen dieser beiden Algenformen näher studiert. Flaschen mit Pollwasser, dessen Gehalt an Organismen und gelöstem Sauerstoff bekannt war, wurden in einem Austernkorb in den Sælö-Poll gehängt, wobei der jeweils zu untersuchende Faktor — Salzgehalt, pH, Nährsalzzugabe, Wassertiefe — variabel gehalten wurde. Die Ergebnisse sind folgende.

Die grünen μ-Algen sind lichtliebend; sie gedeihen am besten bei einem Salzgehalt $< 19\ ^0/_{00}$. Die blaugrünen μ-Algen dagegen sind gedämpftem Lichte angepasst, sie bevorzugen einen Salzgehalt $> 16\ ^0/_{00}$. Die Assimilationstätigkeit der Algen wird wesentlich von der Wasserstoffionenkonzentration beeinflusst. Das Produktionsoptimum der blaugrünen Algen liegt im Gebiet von pH 7.7—8.6, das der grünen Algen zwischen pH 8.5 und 9.1. Erst von pH 9.6 an ist die Vermehrung der Algen sistiert. Zwischen der Sauerstoffproduktion im Pollwasser und dem Zuwachs der blaugrünen Algen herrscht im pH-Gebiet 6.5—9.8 eine gute Übereinstimmung. Diese Algen sind also die Hauptproduzenten im Poll; die für sie optimalen Lichtverhältnisse kommen in einer Tiefe von 0.5—2 m. vor und bedingen hier ein intermediäres Sauerstoff- und pH-Maximum. Sofern genügend Nährstoffe vorhanden sind, ist das Licht der begrenzende Faktor der Produktion. Andernfalls bestimmt der Zugang von Nitraten und Phosphaten die Höhe der Maximalwerte. Es ergibt sich damit die Möglichkeit, durch Düngung des Pollwassers die Produktion zu steigern und die hemmende Wirkung mangelnder Lichtzufuhr auszugleichen. Die Frage, ob Eisen, Mangan und Humus als begrenzende Faktoren der Produktion auftreten können, wird verneint. Der Sauerstoffverbrauch der Mikroorganismen wird vom pH nur wenig beeinflusst, er nimmt dagegen zu mit Abnahme des Salzgehaltes. Bemerkenswert ist, dass von allen mikroskopisch sichtbaren Organismen befreites Pollwasser einen ausgeprägten Sauerstoffverbrauch hat.

Wie P r y t h e r c h nachgewiesen hat, muss das Seewasser eine gewisse Menge Kupfer enthalten, damit die Austernlarven sich normal entwickeln und festheften; sie bedürfen des Kupfers zum Aufbau des Blutfarbstoffes. Es war deshalb wichtig, die Empfindlichkeit der μ-Algen wie der Larven der europäischen Auster gegenüber Kupfer zu untersuchen. Versuche ergaben, dass die Algen am besten bei einem Cu-Gehalt bis zu 0.014 mg./l. gedeihen; ihre Produktionsfähigkeit wird stark herabgesetzt, wenn das Wasser mehr als 0.02 mg./l. enthält. Für die Larven von *Ostrea edulis* liegt die günstigste Cu-Konzentration bei 0.015—0.040 mg./l., also innerhalb derselben Grenzen, die bereits P r y t h e r c h für *Ostrea virginica* angibt. Das Poll- und Fjordwasser enthielt im Sommer 1931 nur Spuren von Kupfer, im allgemeinen 0.004 mg./l. und nie über 0.008 mg./l. Vergleichsversuche ergaben in derartigem Wasser deutlich eine erhöhte Sterblichkeit der Austernlarven gegenüber solchen Kulturen, denen geringe Cu-Mengen zugesetzt worden waren. Bei sehr niedrigem Kupfergehalt des Pollwassers ist deshalb eine Zuführung geringer Mengen von Kupfersulfat ratsam, wobei jedoch mit Rücksicht auf die μ-Algen eine Konzentration von 0.02 mg./l. nicht überschritten werden darf. Erfahrungen am Ostravig-Poll bestätigen dies. Obwohl hier im Sommer 1931 die hydrographischen Verhältnisse günstig waren, reiche Planktonproduktion herrschte und die Austern den ganzen Sommer hindurch laichten, wurde kein Ansatz gefunden. Das Wasser erwies sich als ausserordentlich arm an Kupfer. Anfang September wurde

$CuSO_4$ zugeführt bis zu einer Cu-Konzentration von 0.02 mg./l. Nach Verlauf von zwei Wochen fand sich Brutansatz, im ganzen hefteten sich etwa 500,000 Larven an.

Gelegentlich wurde bei den im Sælö-Poll auftretenden hohen pH-Werten (bis 9.2) beobachtet, dass die Austernlarven geschädigt waren und eingingen. Daraufgerichtete Untersuchungen ergaben, dass pH-Werte bis 9 gut vertragen werden; steigt die Reaktion jedoch über pH 9.1, so nimmt die Sterblichkeit rasch zu, und in wenigen Tagen sind alle Larven tot. Deshalb kann sich in Sommern, die reich an Sonnenschein sind, eine Düngung des Pollwassers ungünstig auswirken, da infolge des starken $C0_2$-Verbrauches des überreichlich sich vermehrenden Planktons das pH leicht diese schädliche Höhe erreichen kann.

R. Kändler.

H. W. Harvey. "On the rate of diatom growth." Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 1. Plymouth, 1933.

This paper deals with the effect of various substances on the photosynthesis and growth of the neritic diatom *Nitzschia closterium.*

Experiments were made by growing cultures of *Nitzschia* at constant temperature and under artificial light, in filtered sea water to which additions of various salts had been made, and by measuring the oxygen exchange of such cultures in light and darkness.

The addition of phosphate, even in small quantities, to a culture which had an excess of nitrate but had finished all the available phosphate, caused an immediate rise in the rate of photosynthesis and respiration, and also division of the cells and the formation of new pigment. In the same way the addition of nitrogen (either as nitrate-N or ammonium-N) to a phosphate-rich but nitrogen-impoverished culture, raised the rate of photosynthesis. From the increase in oxygen production can be calculated the amount of carbon fixed, and the ratio to this of the P and N added. The ratios (1 to 107 or 120 for P, and 1 to 12 for N) are not nearly so high as would be expected from Brandt and Raben's analyses of diatom-rich townettings. Nor does the ratio between P and N to carbon fixed agree with the relative quantities of these elements utilized during the spring diatom outburst in the sea. It is interesting to note in this connection that Kurasige, working with the diatom *Synedra salina* in fresh water, found that it used up three times as much N as P, which corresponds closely to the ratios found in the English Channel in spring. It is probable that different species of diatoms have different requirements.

In experiments on other factors the rate of growth was measured by counting the cells formed in the cultures under observation. The addition of Fe in various forms promoted growth but the author concludes that only a small fraction of the iron added is in a form available for the diatom. An addition of silica was also necessary for maximal growth, even when it was available by solution of the containing flask. The growth-promoting effect of an addition of soil extract is also discussed and it is concluded that, although this may be partly due to the contained Fe, silica and other mineral constituents, yet, since it will increase growth in a culture already heavily enriched with P, N, Fe and silica, it probably also contains some organic material which promotes growth. Other organic extracts had a similar effect.

It has been suggested by Nathansohn and others that one cause of cultures dying down, and of an outburst in the sea coming to an end, may be a kind of auto-intoxication by some compound produced during the

growth of the diatoms. Experiments in which *Nitzschia* was grown in the filtrate from a previous *Nitzschia* culture lend no support to this view. Indeed, such cultures grew rather better than similar cultures in filtered sea water.

Water which had been recently in the form of ice also acted as a growth-promoting substance, at least in summer, presumably because of the trihydrone molecules which it contained. This is interesting in view of the fact that the spring diatom increase in Norwegian waters often follows immediately upon the spring thaw and the influx of this fresh water into the sea.

The experiments indicate that of the various factors which may influence diatom growth in the sea, many are probably as yet unrecognised, while only a few have been carefully studied. The interesting results which Mr. Harvey has obtained should prove a stimulus to further work on the subject. *S. M. M.*

E. Hentschel. "Untersuchungen über das Kleinplankton an den Küsten von Island". Ber. d. deutschen wiss. Komm. für Meeresforschung. N. F., Bd. VI, Heft 4, Leipzig, 1933.

Dr. Hentschel has made a quantitative investigation of the nanno- and microplankton of the coast of Iceland, based on a voyage round the island in 1932 and several smaller cruises.

There are two fundamentally different kinds of water which wash Iceland, the Atlantic water in the south and west, the Arctic water in the north and east. The nature of the plankton is determined definitely in both kinds of water and is quite different, there being many diatoms with characteristic species in each, and besides this the Atlantic water is always plainly recognisable by the Coccolithophoridae. There is a strikingly sharp difference in the plankton of the two waters in the south-east but in the north a gradual mixing takes place, due in both cases to the hydrographical conditions. The structure of the coast, the currents, the formation of eddies, the flow of fresh water and the ascent of deeper water are all important for the neritic plankton.

Although there is a considerable difference in the plankton from season to season and from year to year there is shown to be a regular appearance of certain important forms both neritic and oceanic.

The samples, which were confined to the surface layers were investigated quantitatively by the centrifuge method and also by sediment. The diatoms are naturally the most important of the groups but the Coccolithophoridae occurred in abundance and also Protozoa and Peridiniales. The figures showing the relative quantities of certain forms in some of the catches are very helpful, and the curves and other diagrams, besides lists of species, add much to the clear understanding of the work.

Thalassiosira in the cold water among the diatoms and *Syracosphaera* in the Atlantic water among the Coccolithophoridae are of extreme importance. *Pontosphaera* also among the latter is very common, but is present in both kinds of water.

The biological differences between the two waters is recognisable by a few genera only. In the cold water the diatom *Thalassiosira* with *Eucampia greenlandica* and *Chaetoceros* is characteristic, in the warm water *Cyracosphaera* and the diatoms *Asterionella japonica, Thalassiothrix nitzschioides, Nitzschia seriata* and *Corethron criophilum,* also *Peridinium* and *Diplopsalis.* The gymnodinians prefer the warm water and avoid the cold being twice as plentiful in the intermediate waters as in the cold and

in the warm waters nearly three times as plentiful as in the intermediate waters. *Glenodinium* is very common in the warm waters but is greatly dependant on a low salinity, the influence of glacier water showing striking results at certain stations. The common diatom *Skeletonema* is in both regions at times very abundant. *Pontosphaera* occurs in both warm and cold waters, optimal conditions being those in which strong winds and currents may bring up much food from deeper waters. It is, however, variable in its appearances and on the south coast in 1929 was common, in 1932 much less so. Diatoms were here high in 1932 and low in 1929. This difference is also shown in the north, where at certain stations diatoms are lacking completely in 1929 and *Pontosphaera* poorly represented in 1932.

The warm-water region is much more fully populated with plankton than the cold, as is shown clearly in the curve for the total plankton, the maximum being near Reykjanes in the south-west. The lowest numbers of all are in the east. Although the highest numbers appear with the highest temperature and the lowest with the lowest temperature the total plankton curve does not correspond with the temperature curve, sometimes in the south the numbers being very low and in the north and east comparatively high. The reasons are to be sought in a large number of factors, including food conditions and the identity of the individuals.

Only a few observations are made on the Metazoa. Copepods, Cladocera, Rotifera and the larvae of mussels, echinoderms and especially cirripede larvae all show regional distribution, the last in the neighbourhood of the rocky coasts. The curve for the whole of the Metazoa has two main peaks, a high steep one at the south-east and a lower broad one at the north-west, the two chief regions of nanno-plankton lying between these two in the south-west and east. This agrees with the former work of P a u l s e n (1909) in the same region, who remarks "Where the diatom plankton is dense, plankton animals are ordinarily lacking." *M. V. L.*

W. Klevenhusen. "Die Bevölkerung des Südatlantischen Ozeans mit Corycaeen". Wiss. Ergebn. d. Deutschen Atlant. Exped. a. dem Forschungs und Vermessungsschiff "Meteor" 1925—1927. Bd. XII, Hamburg, 1931.

In preparing this paper Dr. K l e v e n h u s e n has had access to the extensive plankton collections of the "Meteor"-expedition, made on 254 widely distributed stations mainly in the South Atlantic Ocean, and from this material he has been able to give a very complete account of the oceanic distribution of the sixteen species of Corycaeus *(sensu lato)* which occur in that area.

Taken in conjunction with M. D a h l's earlier account of the Corycaeids of the Plankton Expedition, whose field of exploration overlapped that of the "Meteor" between 0° and 20°N., this paper furnishes us with a general survey of almost the whole Atlantic, and forms a framework which will serve to link up other more isolated observations.

The fact that in this wide survey, in which more than 12,000 specimens were examined, no new species and only one new sub-species was found suggests that the list of oceanic species in this group has reached finality. The Corycaeids are inhabitants of the epiplankton, usually of the upper 50 metres and the occurrence of occasional specimens below 200 metres is regarded by the author as abnormal; consequently no additions are to be locked for from future deep-water explorations.

With the exception of *Corycaeus amazonicus*, which was never found far

from the coast of South America, and of *C. africanus*, which was similarly linked with the Gulf of Guinea, the species here recorded have a very irregular distribution. Most species show strong concentrations in areas apparently scattered at random north of the southern surface isotherm of 15° C., but the author has been able to show that there is a probable connection between these concentrations and the combined effects of temperature and of the great ocean currents. The absence or scarcity of species in areas in which they might be expected to occur is, however, as he says, a riddle for which he has no solution to offer. He assumes apparently that no seasonal variation is to be looked for in oceanic waters, since no reference is made in the paper to the dates, covering a period of two years, on which the collections were made. *G. P. F.*

A. G. Nicholls. "On the Biology of *Calanus finmarchicus*. I. Reproduction and Seasonal Distribution in the Clyde Sea-Area during 1932."

S. M. Marshall. "II. Seasonal Variations in the Size of *Calanus finmarchicus* in the Clyde Sea-Area."

A. G. Nicholls. "III. Vertical Distribution and Diurnal Migration in the Clyde Sea-Area."

Journ. Mar. Biol. Assoc., N. S., Vol. XIX, No. 1, pp. 83—164. Plymouth, 1933.

The authors have made a detailed study from three aspects, a study, moreover, which has been carried out at regular intervals throughout a year by uniform methods. Four stations were sampled at fortnightly intervals by means of a vertical net, three further stations being examined quarterly. The area may be regarded as being self contained, being cut off from the sea by shallow bars, particularly at Station IV at the head of Loch Fyne. The results from all stations are not always in complete agreement, a fact which has obviously rendered the authors' task more difficult.

I.

The mesh employed (77 meshes per 1 cm.) was fine enough to retain ova, and all stages from ovum to adult were counted. Dr. Nicholls points out the difficulty of identifying ova and early nauplius stages without unnecessary expenditure of time.

The results may be summarised as follows. Calanus passed the autumn and early winter mainly in Stage V (copepodite); total numbers were high in September and fell steadily to a minimum in March (or April). The maximum in May was attained suddenly and was followed by a sudden decline. Reproduction began in February and there were three clearly marked breeding periods between this and July.

From a consideration of the sequence of events the author concludes that the adult life of females from the autumn stock may be nine weeks, but that for succeeding broods is not more than six or seven. In the earlier part of the year a period of four weeks is needed for an egg to develop into an adult, a result which was confirmed by laboratory experiments. These shewed also that there was an interval of eleven days between ovum and first copepodite, and that each successive moult up to Stage V required three days. The probable life of a Calanus of the spring and summer is two-and-a-half months, that of the specimens produced at the end of the breeding season five or six.

II.

The data for this paper are derived from the collections already discussed, supplemented by special hauls where necessary.

Adults (♂ and ♀) and Stages V and IV only were measured. One of the most striking features of the length-frequency curves of all classes of individuals measured was the great range and the absence of any clearly defined modes. It was not uncommon to find in one sample a range almost as great as that found over the whole year. The explanations which have been suggested for this by G u r n e y and S e y m o u r S e w e l l are examined. Both workers have postulated the existence of adults of two types, arising either by means of an abnormal second moult (G u r n e y), or by differential growth factors (S e w e l l). The author rejects both these hypotheses on the grounds that neither are the length-frequency curves clearly bi-modal, nor was abnormal moulting ever observed. B o g o r o v's suggestion that sex differentiation takes place in Stage V, small individuals giving rise to males and large to females is also rejected. Out of a number of specimens in Stage V of different sizes reared in the laboratory, eight came to maturity; of four large ones, two were males and two females; of four small individuals, all were females.

The possibility that the long and irregular range of sizes may result from a mixture of races or varieties with different geographical range or depth preference, as suggested by S t e u e r, is also rejected. Commenting upon the tendency of larger specimens within one developmental stage to live below the smaller, however, the author suggests that this may represent the first step in the separation of distinct races with individual depth preferences.

Turning now to the causes underlying seasonal variation in (mean) length, which was found to be greatest when the water temperature was low and least when the temperature was high, the author concludes that abundance, or otherwise, of food will not provide an explanation. Whilst the general decrease in size is probably correlated with rise in temperature, temperature alone will not explain the increase, followed by a decrease coincident with great egg production, which was so clearly shewn. The explanation suggested for this is that eggs laid early in the breeding period develop into a large type, whilst those from eggs produced later in the same period give rise to a small type. In the smaller females egg production must be presumed to follow soon after the moult; in the larger it is delayed for several weeks, during which time the numbers of this large type are reduced by normal mortality. It is presumably to this large type that Dr. N i c h o l l s is referring when he says, p. 95, that "Calanus, having moulted into adults, require from three weeks to one month for maturation of the reproductive products ..."

III.

The data for this section are derived mainly from two sets of observations each covering a period of 24 hours in January and July respectively. All copepodite stages were enumerated separately and the counts have provided an interesting comparative study.

The main results may be summarised as follows:

Stages I, II and III (July). Throughout the period of 24 hours the bulk was to be found above 45 metres: there was a slight upward movement in darkness.

Stage IV (July). Save at 10 p.m. and 1 a.m., in the dark, when there was a decided upward migration, specimens in Stage IV were approximately evenly distributed from top to bottom.

Stage V. In January, the main mass was found at all times below 80 metres. In July, it was at a still lower level, save in the darkness when a fair proportion migrated to the surface, returning, however, before dawn. Dr. Nicholls suggests that these may have been the oldest individuals about to moult into adults, *(q. v.)*.

Stage VI, ♀. In both January and July females shewed a definite migration of the type found by Russell (Biol. Rev., Vol. II, 1927). It is interesting to point out, however, that in January the distribution at 4 a.m. and 7 a.m., in the darkness, shewed a remarkable resemblance to the typical kite-shaped figure described by this worker.

Stage VI, ♂ (January). Males were approximately evenly distributed at all times from 30 metres to the bottom, withdrawing slightly in the daytime from the surface and coming a little closer in the night.

We see, then, a gradual preference for the lower levels becoming established as the animals grow older, bridged by Stage IV, the younger individuals of which class tend to behave like those in Stage III, the older like the bottom-living Stage V. When a definite upward movement at night is shewn again by females it would seem impossible to avoid the conclusion that this must be connected with spawning, a brief excursion to and a retreat from the surface being completed in the hours of darkness. The behaviour of males, however, does not fit in with this general scheme, and it is particularly unfortunate that in July males were too scarce to enable their behaviour to be studied.

The paper concludes with observations on the occasional and apparently abnormal occurrences of older Calanus right at the surface in broad daylight, a phenomenon known, too, amongst Euphausiids. The author suggests that this is of a local and temporary nature, due to some potent but as yet undetermined cause. *A. C. G.*

Johan Hjort and **Collaborators.** "Essays on Population." Norske Vid.-Akad. i Oslo, Hvalrådets Skr. Nr. 7, Oslo, 1933.

These essays form contributions to the study of the growth of populations which are of general interest apart from their applicability to fishery research. The data treated and methods used in the essays are so diverse that a combined review of them would not meet the case; accordingly, each is treated separately.

(1). Johan Hjort. "Whales and Whaling (Introductory Remarks)."

After a most interesting account of the comparative anatomy and natural history of the whales, Hjort gives a history of the whaling industry from the days when the Basque fishermen fished for porpoises to the present day, when guns and explosive shells are used for killing the prey, and the whale-ships are accompanied by huge floating factories for dealing with the products of the industry. He emphasises the fact that each kind of whale is dependent on a particular kind of food, and is capable of following this food for almost any distance. The study of the distribution of the various food organisms is thus of the highest importance if the migrations of the whales are to be understood. The author discusses the great efforts that have been made recently to obtain reliable information as to the size of the stock of whales and asserts that, owing to unrestricted fishing, the future of

the industry is by no means secure. "On the contrary," he says, "we must expect either that the industry will establish an equilibrium at a lower level, or that there will be fluctuating periods of successful and unsuccessful whaling". The question of a rational exploitation of the stock is dealt with in another paper (No. 4).

(2) Per Ottestad. "A Mathematical Method for the Study of Growth."

In an introduction the author discusses previous attempts at finding a general method for investigating growth, including Malthus's Law, and the "autocatalytic law." The binomial distribution and Normal Error distribution are discussed shortly. In another section the development of the binomial distribution is dealt with and its limiting case, the Normal distribution. The Normal integral curve or "ogive" is then discussed and short tables are given for fitting the ogive to observations. In a section on Statistical Series and the Binomial Frequency Function, the author shows how certain functions of the observed numbers or measurements may be used as a help in deciding whether these agree with the binomial or the Normal distribution or with the corresponding integral curves. One type of these functions he terms "approximation coefficients". The other functions are the moments μ_2 and μ_1, the "variance" and the arithmetic mean respectively. An example of their use is given. In a section on the growth of unicellular organisms, the author shows that, since a yeast cell propagates itself by gemmation, a population of yeast cells may be regarded as made up of cells of varying age or "birth number". If the growth of a yeast population be measured at intervals of time, the growth between any two points of time may be ascribed to cells of the corresponding "birth number". Various observed growths of yeast, after being analyzed by "birth number" were tested by means of the "approximation coefficients" and found to fit the Normal distribution closely. The growth of the population thus agrees with the corresponding Normal ogive. The idea is then applied to an instance of a human population, the ogive being found to describe approximately the increasing number of students attending Oslo University in a certain period. In a further section the author uses the ogive to describe the decrease in numbers of herrings of the 1904 year-class caught in Norway in the years from 1907 to 1908.

It will be seen thus that Ottestad's proposal consists in fitting the Normal ogive to observations of growth. Of course, growth curves frequently take a sigmoid form and the ogive is a very simple case of a sigmoid curve. I am convinced, however, that this particular sigmoid curve should be considered merely as expressing approximately a growth type arising only very infrequently. There seems no reason to expect that free growth followed by a slow check in growth should produce a curve in which the first differences form a symmetrical curve, except in a very few cases. Surely, the growth and the check in growth can very rarely conform to the same law acting continuously from the very start. This method can hardly be regarded as a general basis for the study of growth. Something much more flexible is required, which will demonstrate, even if it does not explain, the differing action of growth and check. Apart from the method itself, its application in this paper will not appeal to the modern statistician. The use of "approximation coefficients" and functions of the moments in the way described still leaves the ultimate decision to personal judgment. The Theory of Random Sampling, the very foundation stone of modern statistics which replaces the personal judgment of a set of numbers

by a straightforward statistical test, receives no mention in this paper. It has been proved again and again that it is impossible to decide by personal judgment alone, even if aided by such things as "approximation coefficients", whether a set of observations conforms to a given theory. Ottestad's coefficients are given by

$$a(x) = \frac{\psi(x)}{\frac{\mu_1^2}{\mu_2}}$$

where x is any observation, $\psi(x)$ is a function of it, of the next observation, and of the mean and variance, μ_1 and μ_2. As a criterion of fit to the binomial distribution, the nearness to unity of the members of the series $\psi(x)$ is taken. Also $\mu_1 > \mu_2$. If besides, $\mu_1 = 2\mu_2$ approximately, the observations are considered to fit the Normal distribution. Unfortunately, "nearness to unity" is left to personal judgment. Also, for a sample to have a considerable likelihood of having arisen from a Normal population, there is no need for μ_1, to be equal to $2\mu_2$. In the Poisson Series $\mu_1 = \mu_2$, not $2\mu_2$, yet if the mean of a Poisson Series is fairly high, say thirty or more, the distribution is practically normal. This criterion would quite unduly limit the use of the Normal distribution, which is *not* used in modern statistics merely as what Ottestad calls a "descriptive rule", but as the basis of numerous tests of significance of effects. With regards to the author's remarks on skewness on page 47, it should be mentioned that skewness often occurs in samples from a Normal population, that it does not necessarily show heterogeneity, and that combining samples reduces skewness quite as often as it increases it. It is quite easy to test if an observed degree of skewness is significant.

(3) Alf Klem. "On the Growth of Populations of Yeast."

The author says "the paramount aim of this paper has been to make a study, on the broadest possible lines, of the way in which the growth of yeast depends on the environment. The results arrived at, are, therefore, of a somewhat general nature and will prove useful for investigations into the growth of other organisms". The author first describes his methods of investigations and apparatus, which are based on those of O. W. Richards and other workers but include some valuable novelties. Richards's experiment in the growth of yeast in a constant environment is then discussed. The growth is not sigmoid but follows the exponential or compound interest law at first, afterwards becoming linear, owing to the yeast becoming packed in a layer. Further sections deal with yeast growth with known variations of environment. Firstly the hydrogen-ion concentration of the culture medium was varied, and it was proved that in normal cultures variations in pH would not have much effect. Variations in alcohol concentrations are shown to have a marked effect on growth. Variations in dilution of the culture medium are then dealt with as well as variations in the supply of nutrient substances. A section deals with the calculation of curves of growth of yeast, taking as a basis the exponential curve of free growth. The methods used might be useful in interpretation of the growth in higher organisms. A section follows on the effects of poisoning on growth, poisoning by the products of metabolism under differing conditions and with different qualities of yeast. The most interesting result of these experiments and calculations was that, where growth ceased owing to limitation of nutrient material and to accumulation of alcohol,

Guldberg and Waage's Law of reversible chemical reactions was found to hold good with regard to the concentration of sugar and alcohol within the yeast cell. The mathematical treatment of the problems of yeast growth, as detailed in the next section, is of general interest, and might prove very useful in the study of many types of growth or decline. The methods are very easy to apply, and founded on simple hypotheses as expressed in very manageable equations. Three cases are dealt with, namely, (1) growth in constant environment, (2) growth in a limited amount of medium, (3) growth as in (2) but with auto-intoxication. It should be mentioned that if equations be formed showing the amount of a growth-producing substance and a growth-checking substance, when these follow Guldberg and Waage's Law of reversible reactions, and if growth be directly proportional to the first and inversely to the second, we obtain an equation for growth against time, of the same mathematical form as that of Robertson, Pearl and Reed, referred to (rather slightingly) by Ottestad on p. 31 of the essays under review. Klem's work may be said to afford experimental support for the claims of these three authors to have discovered a general law of growth. The idea of reversible reactions may be extended to include reversible phenomena (e. g., heat-cold, saltness-freshness and so on) or even positive and negative deviations from some "optimal" measure of a growth-producing substance or phenomenon, and it will be perceived that most types of growth both of organisms and of populations could be dealt with by the equation referred to. Intermittent growth, such as occurs in fish, could be described by this equation, if the development of the growth producing factor were assumed to follow a harmonic, remembering that growth is *not* reservible.

(4) Hjort, Jahn and Ottestad. "The Optimum Catch".

This paper deals with "the relation between the toll levied by man upon a given stock of animals, and the capacity for renewal shown by that stock". The question of natural fluctuations in the renewal of the stock of spawning cod and herrings in Norway is discussed and the authors conclude that, in these cases, the toll levied by man is unimportant compared with such fluctuations. Superabundant herring food seems to be present each year, so that the growth of individuals is not influenced at all by fluctuations in stock. Stress is laid on the importance of investigating what proportion of food is used for growth and what proportion for the production of energy. The authors contrast the case of the Norwegian herring with those of the Scottish haddock and North Sea plaice, where it has been shown that fishing greatly changes the stock of older fish and tends to level down the effect of natural variations in supply. Individual growth still appears unchanged by this. The decrease in landings of large plaice from the North Sea is discussed and the fact emphasized that to obtain the necessary supply, smaller and smaller fish have had to be landed. The authors remark upon the astonishing capacity for renewal of stock, as demonstrated by the enormous landings of "large" just after the Great War. Yet the intense fishing soon reduced the landings to a point lower than they had ever reached. The possibility of establishing a degree of exploitation based on the "Optimum Catch" is then introduced. The "calculation of a decreasing population on the assumption of a constant percentage diminution" is then dealt with. As an instance of this is described a computation made by Helland of the decrease in the stock of bears in Norway owing to shooting. Helland assumed that the rate of decrease of the stock remains invariable, and assumes that the

numbers shot in the first period and the average of the last three periods give a correct picture of the decreasing stock. What is actually attempted is to fit the curve $y = e^{a+bx}$ to the shootings, and his method is faulty because of his assumption as to the correctness of certain numbers viewed as estimates of the decrease in stock. They are all liable to error. The curve should have been fitted by some method allowing for this. I have done this and find that the compound interest law fits the observations with an average error of about 15%[1]). No simple function of time will allow fully for the change in rate of decrease, but the linear law expresses it fairly well. The chance of a bear's being shot cannot be expected to be always exactly the same. Even if it is, the numbers shot would vary according to the binomial distribution, that is to say, certain deviations from the exact values calculated are only to be expected and cannot be considered significant. Werenskiold's criticism of Helland's method, on the ground that it does not forecast correctly, is not justifiable. A true forecast is only possible if conditions after the period of statistically treated observations remain exactly the same as during that period. If they do remain so, efficient statistical methods will undoubtedly give the truest forecast. The should not be criticised if they do not unless all relevant conditions are exactly known, which is manifestly not so in the case in question.

The authors apply Helland's method to the calculation of the stock of whales in Icelandic waters and the stock of large plaice in the North Sea, employing both a mean percentage decrease and a variable percentage decrease. The estimated stocks work out much the same whichever method is used. A theoretical discussion follows, based on the assumption that the "rate of regeneration" and the "rate of catch" both follow the Normal Error Equation. Regeneration of the stock is then discussed in detail, with a method of computing the changing stock from the numbers of mature whales caught. This method is based on many postulates, some of which are freely stated to be inadmissible. The authors arrive at estimates of stock which at any rate do not conflict with known facts.

All this seems very complicated and appears to offer no advantage over the simple method of fitting the curve $y = e^{a+bx+\cdots}$ to the catches by efficient methods. This allows for regeneration, mortality and so on, the "stock" at any time including, of course, additions by birth, and, if the law of free growth is used as a basis, it should be a simple matter to calculate approximately the "Optimum Catch" which would preserve any desired level of equilibrium between regeneration and fishing. The optimum catch is obviously a variable quantity and is related to the expenditure necessary to obtain any given quantity which itself depends on the level at which the stock is kept by regulating the amount of fishing. The authors themselves point out the fairly close agreement between the figures calculated by their complicated method and those derived by Helland's method, and if the equation he uses, namely $y = e^{a+bx}$ be extended by using further terms in x, we have a perfectly good way of showing how the rate of destruction changes, and the probable effect of restrictions on fishing. The authors emphasize the *methodic* character of this paper, pointing out that its main object is the formulation of mathematical methods for the study of problems relating to growth and decline of populations. The paper is very suggestive but the methods

[1]) The method employed is described in the Johnstone Memorial Volume shortly to be published by the University of Liverpool.

proposed suffer from a want of appreciation of the statistical philosophy which postulates that observed numbers in nature must be viewed as samples, random or otherwise, from a larger population of numbers. The assumption also that the successive growth increments should fit the curve

$$\Delta y = e^{-(x-m)^2}$$

is too restricted. A more adaptable theory would be preferable, such for instance as that adopted by Klem in No. 3, his methods forming special cases of the application of Robertson, Pearl and Reeds "general law."

(5) Hjort, Lie and Ruud. "Norwegian Pelagic Whaling in the Antarctic."

The main object of this paper is the development of statistical standards for comparing the catches of whales and their product from year to year and from area to area. The standard unit catch per unit of work is determined as a blue whale unit per catcher's day's work, and the standard unit factory product per unit of work as a barrel per catcher's day's work. The results of the seasons 1929—30 and 1930—31 are compared in terms of these units, as are also the different factories of which twenty-nine were engaged, and the five areas into which the authors have divided the whole region for comparative purposes. The factories vary widely in efficiency. There seems a tendency on the part of the better-equipped factories to work new areas. In the oldest area, I, the blue whale, which gives the best result in units, appears to be failing. Though the total catch is highest in both seasons in area III, the catch in units per unit of work is highest in area IV, which is the furthest away from the old area I. This is possibly due to the working of the new areas by the most efficient factories. Charts are given of the areas showing for the two seasons when and where the whales were caught and tables give the data dealt with in the text. The methods developed seem well suited to their purpose, the comparison of whaling product in time and space.

H. J. B.-W.

Newfoundland Fishery Research Commission. Annual Report for 1932. Vol. 2, No. 1. Plymouth, 1933.

The second report of this series is a worthy successor to the first, (reviewed in this journal, Vol. VIII, p. 274). Dr. Harold Thompson and his staff, which is evidently active and well directed, seem already to have a firm grasp of the more important of the problems of the Newfoundland fisheries. Here we must leave aside the first 48 pages, which deal tersely and pointedly with handling, processing and marketing, and attempt only a short description of the more biological work.

The classification of water, a very important preliminary step, stands as given in the review of the previous report, except that coastal water (the freshest) is now given a lower limit of 26 salinity in place of 29 (parts per mille). The distribution of the types of water in the spring and autumn of 1932 is described, with the help of admirable tinted charts, and compared with the autumn conditions of 1931. On the Banks and those parts of the coast which shared bank conditions, 1932 was a better fishing year than 1931. This is ascribed to greater influx of both Arctic and Atlantic water in 1932, producing a relatively large body of "mixed"

water (Bank water) "suitable for the multiplication of marine forms of life". The south-western coast, however, experienced a poor cod and squid fishery. This is thought to have been due to the temperature having been too high.

Plankton was more abundant in 1932 than in 1931. Details are given of observations on the Copelata, as an example. These showed preponderance of Arctic and Boreo-Arctic forms in 1932 and of Boreal forms in 1931. Catches of cod larvae are described and related to spawning areas.

The relation of cod catches to temperature is held to be complicated by differing reactions of cod, according to the temperature in which they have grown up, and according to the season of the year. "There is, however, (or will eventually be) an answer according with season of year and locality". Observations made on the Grand Bank showed good fishing (five hauls) in water of 0.1° to 3.7° C., and poor fishing (six hauls) in water of -1.1° to 0°, in the spring. Autumn observations are also given, and those made at Bay Bulls throughout the season, and this subject is to be studied further. In the meanwhile it is suggested that the shore trap fishermen may decide when to set and lift their traps with the help of the thermometer, and that lines should be set where the best temperature occurs. Provisionally a table is given showing the "best temperatures" for different localities and seasons.

The seasonal runs of squid *(Illex)* are important on the Newfoundland coast. In this case the provisional conclusion is that there is an optimum temperature range. Still more important it seems that squid approach with an influx of Atlantic water, observations of which may form a basis for forecasting the subsequent runs.

Investigations are also described dealing with haddock, salmon and "races" of cod. The salmon runs are related to temperature. In northerly material some salmon were found which had spent seven years of parr life in the rivers. The sclerite counting method, described in the previous report, has led to division of the cod stock into four fairly self-contained areas.

M. G.

Alf Dannevig. "On the Age and Growth of the Cod *(Cadus callarias* L.) from the Norwegian Skagerrack Coast." Rep. Norweg. Fish. and Marine Invest. Vol. IV, No. 1. Bergen, 1933.

We have come to expect interesting papers on cod from Dr. Dannevig and the latest contribution has the same general importance as earlier papers, owing to the emphasis on methods.

The scale and otolith methods are examined critically. The otolith method was clearly found to be preferable, and we may turn first to Fig. 13 where a record is given of seasonal observations of the marginal structure in cod otoliths from the Topdalsfjord. The material is grouped according to the calendar year of life and, thereby, this evidence of the reliability of the method is repeated as regards six ages — but irrespective of the year of collection (5 years). It appears from the figure (a table is not given) that the season of transition from opaque to transparent zones, during which both opaque and transparent margins may be collected, lasts only two months, in July and August. In September and October virtually 100% of otoliths had transparent margins. A small proportion of opaque margins was found in November, and the three months of December to February form another season when both kinds of margin may be found. Then from March to June there were four months when every otolith had an opaque margin. We have here indubitable evidence of the regularity of

zone formation in this fjord, in the majority of specimens. Furthermore, the shortness of the transition periods is quite sufficient reason for believing that exceptional structure is only to be found in a negligible proportion of fish, if at all. This must rank as one of the best examples known of justification of an age-determination technique by seasonal observations. The paper does not tell us clearly how many fish were used in this important enquiry. Elsewhere in the paper we find two totals for the Topdalsfjord 1924—1929 material, 1736 (p. 8) for the "total number of cod examined", and 1565 (p. 34), for the number in which zones were counted in both otolith and scales. Perhaps the odd 171 fish had only scales with regenerated centres, or broken otoliths. In any case it seems that, taking all years together, some number between 130 and 145 fish were examined per month, on the average.

Other evidence, from persistence of dominant broods, is not so good, owing to local conditions, which are explained. This is emphasised by comparison with some of Jensen and Hansen's data, which are given.

The otoliths of rather less than 3,000 specimens from the Sondeledfjord were not so regular. In this case they are arranged according to season of observation, instead of year of life, in seven seasons. It is true that in five seasons out of seven 100 % of otoliths with transparent margins was reached in September, making in all 97 to 98 % as the maximum monthly proportion of transparent margins. One cannot judge exactly from the figure, but 2—3 % per annum seems to be the order of the minimum estimate of the error in this ring. In May the percentage with opaque margins is perhaps even a little better. The transition period from nearly all opaque to nearly all transparent lasts three months, June to August. The other transition period extends over five months, October to February, and some few specimens with transparent margins may be taken even to April. Compared with the Topdalsfjord there were in all 3—5 additional months of the unfortunate seasons when otoliths with both kinds of margin were taken. This allows more time for formation of supplementary zones in some not very large proportion of cases. The observations would not reveal these unless they were optically distinguishable, or in so large a proportion as to disturb the regularity of the percentages from month to month.

The main result of our critical discussion of Dannevig's evidence is to show that the otolith method is well established in his area for most of the purposes for which it is likely to be used and that only manifestly absurd results would cause mistrust of otolith readings, even if somewhat extended outside the material for which criticism has been possible. Nevertheless the possibility of a percentage of erroneously marked otoliths should always be borne in mind, and is not definitely precluded by Dannevig's analysis, though less likely in the Topdalsfjord than in the Sondeledfjord material.

The scales are definitely shown to be less useful than the otoliths. The test of seasonal observation of the margin gives better results for the Sondeledfjord otoliths than for the scales. This particular comparison is not made for the Topdalsfjord material, where the otoliths were more satisfactory than in the Sondeledfjord. There is a very interesting discussion of examination of the same material by otoliths and by scales, the scales having been used in four different ways, all told. The results are not accurately the same. In Fig. 16 it is seen that the result of otolith readings differs more from those of the scales than three of the scale methods do from each other. The dominant year-classes are the same by all methods,

but the scales tend to show more zones than do the otoliths, even when all doubtful zones are rejected. It seems, from consideration of the comparison of the evidence of marginal structure in the Sondeledfjord cited above, that the otoliths are more likely to be right.

This review is now already longer than usual, although less than half of Dannevig's paper has been described, so the remainder cannot have the attention that it deserves. We only note the confirmation of an earlier conclusion, that August is the principal time for the formation of narrow zones in the scale, corresponding nearly with transparent zones in the otolith, and with *high* temperature and fairly large length increments. Manifestly it behoves us to make no easy assumption as to the season of formation of "winter-rings", without checking by observation.

The actual labour has been considerable, resulting in no less than 58 pages of tables. The photographs of scales and otoliths are excellent.

M. G.

G. Rollefsen. "The Otoliths of the Cod." Rep. Norweg. Fish. and Marine Invest. Vol. IV, No. 3. Bergen, 1933.

Either Mr. Rollefsen has made a discovery of the very first importance and great practical usefulness, or he has started a hare in whose pursuit we shall all waste a great deal of time. Mr. Rollefsen points out that the outer zones of the cod otolith are often very different in appearance from the inner, "being generally narrower and having a more conspicuous clear (hyaline) band which is often wider than the opaque band, — in contrast to the inner zones where the opaque bands are the widest. ... It seem(s) reasonable to connect this change of ... the zone pattern with a change in the life cycle of the fish, and ... it is difficult to think of a more fundamental change than that caused by the inception of sexual maturity, the ripening of the gonads, the spawning, the fast during spawning, the spawning migration and the stay in a new habitat ... Such narrow outer zones may be found in about 60 % of skrei otoliths while in the immature loddetorsk they are never observed. *It seems, therefore, naturally to regard the narrow zones as spawning zones.*"

It seems obvious that the less we say and the more we do about Mr. Rollefsen's suggestion the better. The remainder of his paper is probably better regarded as a demonstration of what important enquiries can be pursued by the technique, rather than as giving reliable answers to these enquiries. The new technique opens up such possibilities that there is real danger that it will be used before its limitations are known. We need a good series of parallel observations of gonads and otoliths, so as to determine what percentage error may be expected in the assessment of maturity from the otolith. Some percentage error is to be expected. Probably such a collection is already in hand. Also, the "spawning zone" needs to be more exactly related to the life of the fish. For example, one wonders what those other 40 per cent. of skrei, with no spawning zones on their otoliths, are doing at Lofoten. Some of these are accounted for, the "gjeiltorsk", but might the majority be the first spawners, the current season's zone not yet being formed? That is, is the year approaching first maturity distinguished from the previous years, or is it only after first spawning that the altered life makes its record? Would this not make Mr. Rollefsen's estimates all to old by one year?

M. G.

D. S. Raitt. "The Fecundity of the Haddock." Fisheries, Scotland, Sci. Invest., 1932, No. 1. Edinburgh, 1933.

The object of this research was to form an opinion as to whether the progressive reduction in the numbers of the mature haddock, due to intensive trawling, is likely to reduce the spawning capacity of the North Sea haddock stocks. It is a sound and thorough paper, of which an adequate review cannot be given in the space available.

The author gives a brief discussion on the intra-ovarian eggs of Teleosts and defines, with his reasons, the type of egg he has counted in his own fecundity investigations. His counts refer only to eggs in the penultimate (yolky) stage. Since his samples were obtained just before the height of the spawning season, he considers that these yolky eggs are those which are about to be matured and spawned.

Dealing first with the relation between length and fecundity, the author finds that, within each year-class, fecundity increases at a rate greater than the cube of the length of the fish. The influence of age upon fecundity is such that the few precocious mature females two years of age produce far fewer eggs than mature three-year-olds of the same length, but that from three years onwards there is little difference in the spawning capacity of female fish of the same length, though it is possible (and the author is rightly very guarded) that, after the fifth year, the spawning capacity declines somewhat.

The relation between length and weight in the haddock at the time of maximum, mean and minimum weight is dealt with, and it appears that, while for the greater part of the year, weight is proportional to a power of length greater than 3.1, at that time of the year when the weight is at a minimum, it is proportional to a power of length less than 3.1, though greater than 3. (There is surely a slip on page 26, table at foot of page; $W = .0053 \times L^{3.85}$ should read $W = .0053 \times L^{3.085}$). Comparing these results with those on the fecundity of the fish, it appears that fecundity increases in relation to length at a much greater rate than weight does, and that the amplitude of the seasonal variation in weight (due to a transference of material from the somatic tissues to the gonad, and subsequent recovery) increases with length at a greater rate than the weight of the fish. The author is inclined to think that this process must eventually lead to the death of the fish through "over-reproduction". Weight, in each age-class, increases with length at a rate greater than the cube of the length, except in the two-year-old specimens.

Finally, the relation between weight, age, and fecundity is discussed. Two-year-old fish produce far fewer eggs than three-year-old fish of the same weight, but the latter produce slightly more eggs than older fish of the same weight. In fish of the same age and the same length the heavier fish tend to produce the larger number of eggs.

The author concludes that, between its second and third years, the female haddock increases its egg-production to three times, between its second and fifth year, to five, and between its second and sixth year, to nine times that of its second year. He points out, in addenda, that the present heavy rate of overfishing is throwing upon the two and three-year-old fish the brunt of stock replenishment, for which they are decidedly inferior to the older fish, and that this reduced spawning power must be reckoned with in considering the causes of "natural fluctuations" in the strength of the broods entering the fishery each year.

Two-year-old haddock are anomalous, as compared with three-year-old and older haddock, in the rate of onset of maturity, in fecundity (i. e., the

number of eggs in the ovary which develop yolk at the height of the spawning season) and in the relation of weight to length. The reviewer has concluded, in a paper quoted by the author, that the female hake undergoes a season or seasons of adolescence (prior to the first true spawning season) in which a sufficient number of the ovarian eggs enlarge and secrete yolk to distinguish the ovary from an immature ovary. These adolescent hake, however, do not spawn; at the end of the season the yolky eggs are re-absorbed; their body-weight and liver-weight, while greater than those of immature, are definitely less than those of mature hake of the same length. If the author considers the suggestion that his precocious two-year-old mature female haddock are in reality undergoing a season of adolescence, he will find the parallelism with the hake very close indeed, and his difficulties over the two-year-old fish may disappear. The test will be whether he has found two-year-old female haddock containing hyaline eggs.

C. F. H.

J. J. Tesch und **J. de Veen.** "Die Niederländische Seefischerei." Handbuch der Seefischerei Nordeuropas; herausgegeben von H. Lübbert und E. Ehrenbaum. Bd. VII, H. 2. Stuttgart 1933. E. Schweizerbart'sche Verlagsbuchhandlung.

This account of the Dutch sea fisheries, by Tesch and de Veen, is the fourth part issued (of five) of the seventh volume of the "Handbuch" of the Sea Fisheries of Northern Europe. One more part, on the sea fisheries of France, is necessary to complete the seventh volume.

The "Handbuch", which has been published at intervals for some years now, must be well known to all students of the sea fisheries. The parts already issued vary to some extent in their value, some being much better and less controversial than others. It may be said at once that the present part is one of the best. The work is divided into three parts:— the Deep-sea Fisheries, the Coastal Fisheries, and the State and the Fisheries. Of these the third part is very brief, the first two detailed.

The great Dutch deep-sea fishery is the Herring Fishery and the authors deal with this in a practical and entertaining manner. The historical side is given the importance it deserves and the authors are to be congratulated, not only on the description in the text but also on the selection of illustrations of types of fishing vessels, showing the development of the great deep-sea herring fishing from its earliest stages.

This section of the book is undoubtedly of the greatest interest to the general reader.

Following the historical section there is a detailed account of the present condition of the various branches of the Dutch sea fisheries, both herring and trawl. The present Dutch herring fishery is only a shadow of its great past; in 1930 there were 53 steam and 237 motor drifters registered in Holland. The Dutch trawl fisheries are divided into three parts: — the coastal fishery, the winter fishery of the herring boats, and the steam trawler industry, which last is based on Ymuiden. There were 209 steam trawlers registered in Holland in 1930 so it has a relatively important industry. At the commencement most of the steam trawlers were purchased in England, but subsequently they were built in Holland. Quite recently (in 1931) there has been a marked development of motor trawling in Holland.

The coastal fisheries are next described and here again, as in fact all through the book, the illustrations are well selected and elucidate the text in a practical and praiseworthy manner. Much of the detailed account of

the Dutch shell fisheries must, however, be looked for in Havinga's account of Oyster and Mussel Culture in the fifth part of this same volume (VII).

The last section deals with the State and the Fisheries and the only complaint we have to make is that we should have liked more detail here. From the point of view of persons concerned with fishery administration this section is too brief.

But having regard to the space at the authors' disposal we cannot see how this account of the sea fisheries of Holland could have been improved, and after all there is a satisfactory bibliography to which the serious student can refer for further detail. In conclusion we think the authors are to be congratulated on this "Heft" which fully maintains the generally high character of the Handbuch and is superior to some of the other parts already issued.

Owing to the fall in value of English currency the price of this part appears to be rather high for the private purchaser, but presumably it would be unreasonable to complain of this, as it is a factor beyond the control of the authors or publishers. We hope, nevertheless, that succeeding parts will be published at as reasonable a price as possible.

J. T. J.

A. Willer. "Untersuchungen über das Wachstum von Fischen. V. Untersuchungen über Wachstumsbeeinflussung bei Bachforellenbrut durch Änderungen des Sauerstoffgehaltes des Brutwassers." Zeitschr. f. Fischerei. Bd. XXXI. H. 3. Neudamm u. Berlin, 1933.

In some previous work, an account of which was published in Zeitschr. f. Fisch. Bd. XXVI. 1928, Dr. Willer found that trout fry, both in the egg and after hatching, were smaller when kept in water of low oxygen content than in water more fully aerated. The present paper follows up this observation in more detail.

Six tanks were stocked with eggs from one female brown trout *(Salmo trutta)* fertilised by milt from the same male. These tanks were supplied with water of different oxygen concentrations: in tank I the oxygen content varied from 18 to 24 per cent. of the saturation value, in tank II from 23·5 to 46·6, in tank III from 48·4 to 62·3, in tank IV from 60·0 to 76·5, in tank V from 61 to 92, while tank VI was a control supplied with water from the commercial hatchery at Perteltnicken where these experiments were carried out. The oxygen content of this water varied from 32 to 49 per cent. of the saturation value.

The fry in all tanks hatched practically simultaneously and a week after the hatching was complete the length of the fry was measured. It was found that the average length of the fry in tank I was smaller than that of those in tank II, which was itself smaller than those of the fry in the other tanks. In these other tanks the size was found to be approximately the same, such differences as occurred appearing to be without significance. A second measurement a month later showed that all the fry had increased their length at about the same rate, so that the size differences persisted. From this time, however, until the experiment was concluded five weeks later, the fry in tanks III, IV and VI continued to grow in length much more slowly while those in tanks I and II maintained the same rate until they reached the same average length as the others. Before this stage was reached all the fry in tank V had died and were therefore not available for comparison.

It seems, then, that Dr. Willer has shown that low concentrations of dissolved oxygen affect the growth of the embryo within the egg, so that

it hatches at a length less than normal, but, having hatched, the fry make up this deficiency and become of normal size. It is unfortunate that towards the end of the experiment the number of fish in some tanks had become so small that the averages they give may be of little significance.

Dr. Willer appears to believe that there is an optimum concentration of oxygen for the development of trout and that this optimum is between 50 and 60 per cent. of the saturation value. While he has shown that in low oxygen concentrations the fry are small when hatched, his evidence for the upper limit is unsatisfactory and is based mainly on the heavy mortality which occurred in tank V and he proposes to investigate this question further. In view of the fact that in England commercial hatcheries endeavour to maintain their water supplies at as high a level of oxygenation as possible it seems unlikely that this upper limit will be found below the saturation value.

To many it will be surprising that trout fry can exist in such de-aerated water as Dr. Willer used. There is, particularly in England, a good deal of ignorance of the amount of oxygen trout actually need and evidence is accumulating to show that, provided other conditions are satisfactory, it has been greatly over-estimated.

Dr. Willer himself suggests, and it is very desirable, that in future work of this kind the weight as well as the length of the fish should be measured. Then it may be possible to discover the physiological basis of these facts which he has discovered. *F. T. K. Pentelow.*

K. Brandt† und J. Reibisch. "Der Stoffhaushalt im Meere." Handbuch der Seefischerei Nordeuropas, Bd. I, H. 6; herausgegeben von H. Lübbert und E. Ehrenbaum, E. Schweizerbartsche Verlagsbuchhandlung, Stuttgart, 1933.

Nach einleitenden Bemerkungen über den Kreislauf des Stoffes im Meere im allgemeinen ist der Stoffwechsel der lebenden Pflanzen, Tiere und Bakterien eingehender behandelt. Im *Baustoffwechsel* wird aus der aufgenommenen Nahrung das Material für das Wachstum und für den Ersatz der beim Betriebsstoffwechsel verbrauchten Bestandteile des Körpers gebildet, während die Energie für die Lebensvorgänge durch Zersetzung der hochkomplizierten organischen Stoffe, hauptsächlich vermittels der Atmung, im *Betriebsstoffwechsel* gewonnen wird.

Im Meere bestehen zwei Lebensgemeinschaften nebeneinander. Die des freien Wassers setzt sich zusammen aus dem Plankton und den gut schwimmenden grösseren Tieren, deren ganzer Lebenskreislauf unabhängig vom Boden im freien Wasser abläuft. Während der Lebewelt des freien Wassers am Lande nichts an die Seite zu stellen ist, entspricht die des Bodens dem Leben auf dem Festlande. Die Jugendformen der meisten Bodentiere vermitteln als Planktonten den Übergang zwischen den beiden Lebensgemeinschaften.

Da die Pflanzen als die Stofferzeuger unter Verwertung der Energie des Sonnenlichtes aus einfachen anorganischen Verbindungen die höheren organischen Verbindungen aufbauen — im Meer sind es hauptsächlich mikroskopische, einzellige Planktonalgen —, bilden ihre Produktionsbedingungen die Grundlage für den Stoffumsatz überhaupt. Von den eigentlichen *Ernährungsbedingungen* hängen Wachstum und Vermehrung unmittelbar ab. Zu ihnen gehören im freien Wasser Licht und Wärme als energetische sowie die unentbehrlichen Nährstoffe der Pflanzen als chemische Wachstumsfaktoren. Gute Ernährungsbedingungen beschleunigen, ungünstige verlangsamen das Wachstum. Dabei ermöglichen aber normale *Lebensbedingungen*,

die für die einzelnen Arten verschieden sind, erst den Ablauf der Lebensvorgänge überhaupt. Hierher gehören Höhe des Salzgehaltes, freier Sauerstoff, Alkalinitätsgrad, Temperatur, sowie Abwesenheit schädlicher (giftiger) Stoffe. Die *indirekten Produktionsbedingungen* bewirken, dass jeweils die zum Leben erforderlichen Bedingungen erhalten bleiben. Dem Kreislauf des Wassers auf der Erde und den verschiedenen Bewegungsformen im Meerwasser fällt dabei eine wichtige Rolle zu.

Einige der notwendigen Pflanzennährstoffe sind in so geringen Spuren vorhanden, dass von ihnen — den Minimumfaktoren — die Stofferzeugung in erster Linie abhängt. Es sind das im Meere ebenso wie auf dem Lande Phosphorsäure und Stickstoffverbindungen, deren wechselnde Menge in den verschiedenen Jahreszeiten die Produktion organischer Substanz ausschlaggebend beherrscht.

Die Tiere brauchen für ihren Stoffumsatz die von den Pflanzen erzeugten organischen Stoffe, die Kohlehydrate (Stärke, Zucker), Fette und Eiweiss. Durch deren Zersetzung gewinnen sie die Energien für ihre Lebensäusserungen und liefern in den Zerfallsprodukten wieder die notwendigen Pflanzennährstoffe. Damit ist der Kreislauf der Stoffe geschlossen.

Die Aufnahme und die Art der Verarbeitung der Nährstoffe durch die Meerestiere ist sehr verschieden. Für Wassertiere ist eine sehr häufige Art der Nahrungsbeschaffung das Heranstrudeln kleinster geformter Nahrung. Der für die Einverleibung der Nahrung erforderliche teilweise chemische Abbau geht entweder schon in besonderen mit der Aussenwelt zusammenhängenden Hohlräumen (Darm) vor sich oder spielt sich erst im Innern der Körperzellen selbst ab, so vor allen bei den einzelligen Tieren.

Weiter wird das Auftreten lebender Pflanzen im Tierkörper (Symbiose) an Beispielen behandelt und zuletzt die Bedeutung gelöster Nährstoffe für die Meerestiere erörtert und auf ein sehr geringes Maass zurückgeführt.

J. R.

P. Kuckuck. "Der Strandwanderer. Die wichtigsten Strandpflanzen, Meeresalgen und Seetiere der Nord- und Ostsee." J. F. Lehmanns Verlag, München, 1933.

The original edition (1905) of this excellent little book was prepared by the late Dr. Kuckuck, a distinguished botanist and Kustos of the Biologische Anstalt at Helgoland. After his death in 1918 the Biol. Anstalt undertook responsibility for the subsequent editions, and the present one, the fifth enlarged and revised edition, has been edited by Prof. Dr. A. Hagmeier.

The book is intended to serve as a handy guide for the identification of the commoner seashore plants, marine algae and littoral animals likely to be met with by the amateur naturalist on the North Sea and Baltic coasts of Germany. There is a general introduction on the ecology of the shore by Dr. Hagmeier, and the remainder of the book is taken up by short but adequate diagnoses of the principal species of animals and plants likely to be found. The task of diagnosis is greatly lightened by a series of excellent colour plates, of which 4 display shore plants, 6 marine algae, and 15 marine animals. The drawings are vigorous and characteristic, and the colours lifelike. In addition, there is a short section by Dr. Weigold on sea birds, with 8 uncoloured plates.

The book, which is produced at a cheap price, can be unreservedly recommended.

E. S. R.

W. Benecke. "Bakteriologie des Meeres." Handb. d. biolog. Arbeitsmeth. (Abderhalden). Abt. IX, Teil 5, Heft 6 (Schluss). Berlin, 1933.

This section of Abderhalden's Handbuch is devoted to a detailed historical review of the accumulated knowledge of marine bacteria and their rôle in the transformation of elements in the sea. It comprises 122 pages of text, with numerous footnotes and 16 pages of bibliography. The mere listing of the subsections is sufficient to give an idea of the breadth and scope of the subject;

I. Introductory. Methods of marine bacteriology. Historical development of marine bacteriology. Localization of marine bacteria. II. Cultivation of heterotrophic bacteria from sea water. From B. Fischer, 1886, to 1900. III. Cultivation of heterotrophic bacteria from sea water. From 1901 to 1932. IV. Direct microscopic examination of marine bacteria. V. Marine bacteria and soil bacteria, and transition forms between them. VI. Sea water as a natural medium for plankton bacteria. VII. Transformation of various organic compounds by marine bacteria. Purple bacteria (Athiorhodaceae). VIII. Epiphytic and parasitic marine bacteria. Some morphologically characteristic marine bacteria. IX. Bacteria and the cycle of nitrogen in the Sea. Denitrification. X. Bacteria and the cycle of nitrogen in the sea. Nitrification. Nitrogen-fixation. XI. Bacteria and the cycle of sulphur in the sea. Sulphate reduction and other hydrating processes. XII. Bacteria and the cycle of sulphur in the sea. Oxidation of sulphur compounds by colorless, purple, and green sulphur-bacteria. XIII. Bacteriogenic marine sediments. XIV. Economic problems. Destruction by bacteria of sea fish and other marine animals used for human nutrition.

Prof. Benecke states in the introduction that in principle the methods and apparatus used in marine bacteriology are practically the same as those used in water bacteriology in general. The preparation of media for the isolation and cultivation of bacteria is similar to that used in general bacteriology except that sea water has to be substituted for tap or distilled water. The marine bacteriologist will be interested in determining whether the bacteria isolated from the sea are obligate halophites, whether they are able to grow better in sea water than in freshwater media ("halophilic bacteria") or whether, in spite of their derivation from the sea, they are able to grow in fresh water just as well or even better than in sea water.

Marine bacteriology progressed from the study of forms concerned in protein decomposition ("putrefaction") and similar processes of decomposition of organic substances in the sea to the study of organisms with a highly specialized metabolism, such as those that liquefy agar, reduce nitrate, oxidize ammonium salts, oxidize inorganic sulphur compounds and bring about the formation of sediments in the sea. In addition to the important functions that bacteria play in the cycle of life in the sea, they also bring about various diseases of fishes, molluscs, and other economically important forms of marine life.

This summary of the present status of marine bacteriology prepared by Prof. Benecke should not be considered in the light of a textbook or treatise, especially since it lacks completely tables, charts, or figures, but more as a detailed bibliographic compilation of the historical development of the subject. As such it is very complete and will be appreciated by everybody interested in the rôle of bacteria in the cycle of life in the sea.

S. A. W.

R. M. Bond. "A Contribution to the Study of the Natural Food-Cycle in Aquatic Environments, with particular consideration of micro-organisms and dissolved organic matter." Bull. Bingham Ocean. Coll., Peabody Mus. Nat. Hist. Yale Univ. Vol. IV, Art. 4. New Haven, Conn., 1933.

This interesting and valuable paper forms a useful supplement to Krogh's paper which was recently reviewed in this Journal (Vol. VII, pp. 313—315). The latter was concerned chiefly with a critical analysis of Pütter's experimental technique and general conclusions, whereas Bond sets out "to discover more about the absolute and relative quantities of possible foods in the sea — especially concentrating upon the nannoplankton; and also to experiment on parenteral feeding, with a suitable animal, under most carefully controlled conditions."

Using an improved modification of the permanganate method, he found that in East Sound in Washington State dissolved organic matter averaged 76.9 % of the whole organic matter, the remainder being about equally divided between phytoplankton and nannoplankton. The importance of the latter is strongly emphasized, and rightly so, and attention drawn to Lohmann's significant statement that, when estimating the value of any form as food, the rapidity of reproduction is just as important as its actual abundance at any time. In this connection, although he agrees with Krogh that the bulk of the dissolved organic matter is probably in a form incapable of assimilation by animals, Bond finds that the speed of reproduction of nannoplankton, such as the ciliate, *Colpidium campylum*, and a veriety of unicellular algae, is materially increased in the presence of various dissolved organic substances. He considers that any effect the latter may have on the zooplankton is exerted in this indirect way.

Bond is inclined, from a consideration of literature and from his own, somewhat inconclusive, experiments, to put too much weight on the possible permeability of the chitinous integument. If the reviewer's own work on the permeability of the uncalcified chitin of Decapod Crustacea is any criterion, this is excessively slight except for fat solvents. He is on safer ground when he accounts for the positive results of previous experiments on the apparent use of dissolved organic matter by aquatic animals as due either to its absorption by the gut or to the growth of bacteria which are ingested. Bond's own experiments on *Artemia* are not open to the latter criticism. He first sterilized eggs with $HgCl_2$ and then reared them in various sterilized "nutrient" solutions. In no case was growth prolonged after the exhaustion of the yoke. On the other hand continued growth did occur in the presence of various unicellular algae, bacteria or of living or dead *Colpidium campylum*.

The definite conclusion is arrived at that *Artemia* depends on particulate food only, and Bond then proceeds to follow up the argument by a consideration of the efficiency of feeding mechanisms in the zooplankton. Here he is handicapped by an apparently very incomplete knowledge of the literature. He finds evidence of the presence of proteases, amylase and lipase in the gut of *Artemia* — as indeed was only to be expected but he has as justification for his examination Pütter's statement that the gut of the entomostracans does not apparently contain digestive enzymes! Bond makes the same criticism of statements on the emptiness of the guts of zooplankton that the reviewer has made of similar statements about corals, namely that unless the animals are collected when actually feeding and then examined or fixed at once, loss through digestion and defecation renders any examination of their gut contents useless.

Bond's results re-emphasize the importance of the nannoplankton in the food of the zooplankton and also indicate the possible influence on the increase of the nannoplankton of the dissolved organic matter. This is as it should be. There can be no question as to the fundamental importance of the nannoplankton in the food chains in the sea. Further work along these lines is one of the most urgent needs of marine biology.

C. M. Yonge.

Reviews of recent Russian literature.

By

Prof. **A. L. Behning.**

E. S. Sinova. "Les algues de Kamtschatka." Explor. des mers d'U.R.S.S. Fasc. 17, 7—42. Leningrad, 1933.

Auf Grund der Bearbeitung eines reichhaltigen Materials, welches namentlich in den Jahren 1929—1930 von den Expeditionen des Hydrologischen Institutes und des Wissenschaftlichen Forschungs-Institutes in Wladiwostok eingesammelt worden ist, beschreibt die Verfasserin 73 Algenarten (Chlorophyceae, Schizophyceae, Phaeophyceae, Rhodophyceae), von welchen besonders hervorgehoben seien: *Chlorochytrium schmitzii, Dermocarpa prasina, Nitophyllum ruthenicum, Phymatolithon compactum, Iridaea phyllocarpa, Iridaea pustulosa, Delesseria alata, Delesseria spinulosa, Laminaria dentigera, Laminaria longipes, Alaria fistulosa, Alaria pylaii.* Die in grossen Mengen in der Bucht von Awatschinsk vorkommenden grossen Formen von Laminaria und Alaria (bis 5 m. Länge bei einer Breite von bis 40 cm.) spielen eine grosse Rolle als Ausfuhrobjekte nach China. Die bei den Karaga-Inseln massenhaft auftretenden Ptilota zeigen einen Jodgehalt von 0.19—0.27 %.

L. K. Losina-Losinsky. "Die Pantopoden der östlichen Meere der USSR." Explor. des mers d'U.R.S.S. Fasc. 17, 43—80. Leningrad, 1933.

Verfasser hat die grosse Ausbeute des Hydrologischen Institutes und der Fischerei-Station in Wladiwostok (1925—1931) bearbeitet. Es werden beschrieben: *Lecythorynchus marginatus, Halosoma derjugini, Ammothea alaskensis, Phoxichilidium femoratum, Nymphon longitarse,* var. *brevicollis, Nymphon grossipes, Nymphon brevirostre, Nymphon hodgsoni, Nymphon striatum.* Als neue Arten erwiesen sich: *Pycnosoma* (gen. nov.) *strongylocentroti, Ammothea lavrentii, Ammothea uschakovi, Ammothea litke,* var. *intermedia, Ammothea echinata* subsp. *orientalis, Ammothea borealis* subsp. *japonica, Ammothea gracilipes* var. *borealis, Nymphon uniunguiculatum.*

Diese Befunde zeigen uns wieder eine Reihe von Formen, welche auf eine Ähnlichkeit zwischen den Organismen der nördlichen Breiten des Stillen und des Atlantischen Ozeans hinweisen. Einige hier gefundene Bewohner der Tropenregion leben ausschliesslich in grossen Tiefen, dagegen zeigen einige Flachwasserbewohner auf eine Ähnlichkeit zwischen der Fauna des Stillen Ozeans und derjenigen des Mittelmeers, Atlantischen Ozeans und der Barents-See.

H. Broch. "Über einige geographisch interessanten Fundstellen von Alcyonarien und Hydrokorallen im nördlichen Stillen Ozean." Explor. des mers d'U.R.S.S. Fasc. 17, 81—86. Leningrad, 1933.

Beschrieben werden *Eunephthya rubiformis, Eunephthya fruticosa* und *Stylaster boreopacificus* nov. sp. Die Fundstellen der beiden Alcyonarien — Ochotskisches Meer — erweitern gegen Süden stark die bisher bekannten Lebensbezirke. Die neue Stylaster-Art aus der Japan-See ist nahe verwandt der atlantischen *St. norvegicus.*

Eu. F. Gurjanowa. "Contribution to the Isopoda fauna of the Pacific Ocean." Explor. des mers d'U.R.S.S. Fasc. 17, 87—106. Leningrad, 1933.

Die grosse Ausbeute aus den Gewässern des Stillen Ozeans (Ochotskisches Meer, Bering Meer, Japanisches Meer), welche die Verfasserin gegenwärtig bearbeitet, birgt eine Anzahl interessanter neuer Arten. Hier werden beschrieben: *Arcturus ulbani, A. setosus,* var. *seminudus,* var. *acuticaudalis, A. crenulatus, Idothea derjugini, I. aleutica, I. orientalis, I. ochotensis, Synidothea bicuspida* subsp. *lata, S. longicirra, S. cinerea, S. spinosa, S. brazhnikovi, S. excavata, Tecticeps glaber, T. renoculis* var. *carinatus, Exosphaeroma ovata, Ligia cinerascens.*

M. I. Markun. "Die Aralsee-Barbe, ihre Systematik und Biologie." Rep. of the Aral-Sea division of the Sci. Inst. of Marine Fisheries, II, 1—48. Aralsk, 1933.

Im Aralsee finden wir das Hauptverbreitungsgebiet der Barbe, welche hier jährlich in Mengen bis zu etwa 1700 metr. tons erbeutet wird. Es leben im Gebiet 2 Arten: *Barbus brachycephalus* Kessl. und *B. capito conocephalus* Kessl., jedoch kommt nur der ersten eine wirtschaftliche Bedeutung zu. Verfasser berichtet über seine morphometrischen, biologischen und fischereiwirtschaftlichen Untersuchungen. Wir haben hier einen Wanderfisch vor uns, welcher zum Laichen in die Flüsse (namentlich die Amu-Darja) aufsteigt. Die Frühjahrswanderung, im März—April, ist kurz, intensiver und länger die Sommerwanderung, im Juli—August. Mittlere Grösse der Wanderfische: Weibchen-74 und Männchen-67 cm., Gewicht 6.4, bzw. 4.5 kg. Als Nebenfang trifft man den sogen. "Panachan", welcher durch seinen niedrigen Körper und Kopf ausgezeichnet ist; bei gleich grosser Länge wiegen diese nur 38.5 % der normalen Form. Es sind das schon abgelaichte und stark abgehungerte Fische. Der Hauptfang dieses Fisches erfolgt in den Gebieten des südlichen Teiles des Meeres.

S. I. Jagudina. "Dynamik des Fischfanges am Aralsee in den Jahren 1929 bis 1931." Rep. of the Aral-Sea division of the Sci. Inst. of Marine Fisheries, II, 49—102. Aralsk, 1933.

Der gesamte Fangertrag beträgt in den letzten Jahren ca. 400,000 Zentner, die grösste Rolle spielen in den Fängen Blei *(Abramis brama)* und Karpfen *(Cyprinus carpio),* welche zusammen 50—60 % des Gesamtfanges ausmachen. Ferner folgen die Plötze *(Rutilus rutilus aralensis),* der Wels *(Silurus glanis),* der Hecht *(Esox lucius),* Schemaja *(Chalcalburnus chalcoides)* und die Barbe *(Barbus brachycephalus).* Ein Abnehmen zeigen die Fänge der einzigen hier im Meere lebenden Störart, *Acipenser nudiventris.*

B. S. Iljin. "Biocoenose des halistatischen Gebiets des Schwarzen Meeres." Priroda, 7, 63—65. Leningrad, 1933.

Verfasser berichtet über einige Befunde, welche er als Mitglied der Schwarzes-Meer-Expedition Knipowitsch's gemacht. Die weit von den Ufern entfernten Gebiete des Meeres sind durch eine Reihe charakteristischer und sonst hier im Meer nie oder nur selten anzutreffender Formen gekennzeichnet: *Idothea algirica, Syngnathus schmidti, Nautilograpsus minutus* und *Gasterosteus aculeatus* Die Formen wurden zwischen Zosteramassen und diversen pflanzlichen Anschwemmungen oder auch freischwimmend gefunden und sind als meist speziell diesem Lebensbezirk angepasste Organismen zu bezeichnen: gutes Schwimmvermögen der Krebse, Körperauswüchse bei *Syngnathus*, typische Meeresfärbung von *Gasterosteus* — oben bläulich schimmernd und die Bauchseite silberglänzend. Die hier vorliegenden Milieuverhältnisse sind: geringe Wasserbewegung, grosse Wasserdurchsichtigkeit, festes Substrat nur in Form von schwimmenden *Zostera* und anderen Pflanzenresten.

G. F. Uhl. "Zur Frage über die Navigationsklassifikation der Küstenmeerboden." Explor. des mers d'U.S.S.R. Fasc. 16, 1—22. Leningrad, 1932.

In der letzten Zeit sind in der U.S.S.R. verschiedene Vorschläge zur Unifikation der Bodenartenklassifikation gemacht worden, so z. B. von Messer, 1930, Gluschkoff, 1930, Derjugin, 1928. Verfasser resümiert seine im allgemeinen mit den genannten summierenden Ansichten folgendermassen:

Klasse	Morpholog. Eigenschaften	Bestimmung	Durchmesser der einzelnen Teile
1	Plastisch	Ton	< 0.001 mm
2	Staubig	Schlamm	0.1—0.001 mm
3	Körnig	Sand	0.1—0.3 mm
4	Einzelkörnig	Kies	10—1 mm
5	Agglomerat	Gerölle, grosse und kleine Steine	100—10 mm
6	Scheuersteine und Blöcke	Grosse Steine	
7	Massiv	Fester Boden, Quadergestein	
8	Organogen	Muscheln, Eisen-, Magnesiale Knollen	
9	Tierische Organismen	Schwämme, Korallen, Lithotamnien	
10	Pflanzliche Überzüge	Gras, Algen	

L. Retowski "Beobachtungen an marinen Kleingewässern der Murmanküste". Trans. Arctic Inst., III, 2, 29—46, Leningrad, 1933.

Verfasser stellte Beobachtungen über diverse sich als Resultat der Meeresfluten an den steilen Granitabhängen der Murmanküste bei Portschnicha bildenden Kleingewässer an. Er teilt sie ein:

I. Periodisch vom Meer überflutete
   a) 11 Stunden unter dem Meeresspiegel, 1 Stunde frei,
   b) je 6 Stunden unter Wasser und 6 St. frei,
   c) 11 Stunden frei und 1 St. unter Wasser.

II. Nur bei Springflut von einzelnen Wellen überflutete Kleingewässer.

In den Gewässern I macht sich in der chemischen Wasserzusammensetzung kaum ein Unterschied zwischen derjenigen des Litorals bemerkbar, dasselbe gilt bei I a auch für die Fauna. In den Gewässern I b bemerkt man eine besonders reiche Fauna, namentlich aus *Mytilus edulis, Littorina rudis* und *Balanus balanoides* bestehend. I c ist arm an Organismen, scheinbar durch die Temperaturverhältnisse bewirkt. Die Gewässer II stellen sich als stark in hydrologischer Hinsicht modifizierende Gebilde dar (starker Salzgehalt, Abhängigkeit der Wassertemperatur von der Lufttemperatur, besonderer Gasgehalt), dementsprechend sind die Lebensverhältnisse hier eng beschränkt.

Ferner wird noch kurz über die durch Süsswasser gebildeten Gewässer berichtet, welche jedoch noch unvollständig erforscht sind.

E. Bajarunass. "Zur Frage über die Bestimmung des Chlorkoeffizienten im Wasser des Schwarzen Meeres". Hydrochem. Materialien, VIII, 82—86. Nowotscherkassk, 1932.

Wie bekannt, verhalten sich in unseren grossen Binnenmeeren und z. T. auch noch im Schwarzen Meere die einzelnen Salzbestandteile anders zueinander als das gewöhnlich im Ozeanwasser der Fall ist. Namentlich verschieden sind hier, und zwar viel höher, die Sulphate. Deshalb erscheinen beim Bestimmen des allgemeinen Salzgehalts nach den üblichen Chloranalysen auf Grund der bewährten Hydrographischen Tabellen von K n u d s e n hierselbst gewisse Schwierigkeiten, die es in einzelnen Fällen ganz unmöglich machen die Tabellen zu benutzen.

Verfasserin hat nun die Gewichtsbeziehungen des trockenen Rückstandes zum Chlorgewicht im Wasser des nordöstlichen Teiles des Schwarzen Meeres untersucht, mit Anwendung einer von E f r e m o f f eingeführten Methode zur Bestimmung des Trockenrückstandes (Abdampfen mit Soda) und stellt dabei den mittleren Chlor-Koeffizient für dieses Wasser gleich 1.8154 fest, mit Schwankungen zwischen 1.7911 und 1.8307.

Ähnliche Bestimmungen für den Kaspisee und besonders den Aralsee, wo wir einen noch viel grösseren Gehalt an Sulphaten im Meerwasser haben, sind sehr erwünscht und zeitgemäss.

N. M. Knipowitsch. "Hydrologische Untersuchungen im Asowschen Meere". Abh. d. wiss. Fischerei-Exped. im Asowschen und Schwarzen Meer, L. 5, 1—496. Moskau, 1932.

Der Senior der russischen Hydrologen berichtet hier über seine 1922—1926 und z. T. auch noch 1927—28 ausgeführten grossangelegten Untersuchungen der hydrologischen und hydrobiologischen Verhältnisse unserer südlichen Meere. Dieser Band ist speziell dem Asowschen Meer gewidmet. Die einzelnen Kapitel sind: Lage und Oberfläche des Meeres; Bodenrelief; Niveau; allgemeine hydrologische Verhältnisse; Wassertemperatur; Salinität; Gasverhältnisse; Wasserdurchsichtigkeit; Eisverhältnisse; Strömungen im Asowschen Meere; Rolle der hydrologischen Faktoren in der Biologie und Fischerei dieses Meeres; Existenzbedingungen der Fische und die Fischerei. Wir haben hier ein Brackwassermeer vor uns mit einem Salzgehalt von ungefähr 10.5—11.5 $^0/_{00}$, in dem die Gefriertemperatur niedriger ist als diejenige der maximalen Dichte. Daraus erfolgt, dass sich hier in den Bodenschichten bei stillem Wetter im Herbst relativ hohe Wassertemperatur längere Zeit erhalten kann. Die vertikale Zirkulation verläuft hier in vier verschiedenen Formen: 1) durch Temperaturzunahme, ohne Veränderungen

im Salzgehalt, 2) durch ebensolche Abnahme der Temperatur, 3) durch Temperaturzunahme mit Salzgehaltserhöhung infolge von Verdunstung und 4) durch Temperaturabnahme bis zum Gefrierpunkt mit Salzgehaltszunahme infolge von Salzausscheidung bei der Eisbildung. Dank der nur geringen Tiefe (mittlere Tiefe 7.22 m.; Tiefen von 10—13.25 m. nehmen nur 50.23 % der Oberfläche ein) werden bei Wind alle Wasserschichten vermischt, durchgreifend beleuchtet und dank der besonderen Lage erfolgt ein grosser Zufluss vom Land her, welcher infolge der Mengen von eingeführten organischen und anorganischen Stoffen in gelöstem und ungelöstem Zustande eine mächtige Entwicklung des organischen Lebens hierselbst ermöglicht. Plankton und Benthos zeigen im allgemeinen eine geringe qualitative, jedoch reiche quantitative Entwicklung. Es sind zumeist Mischformen, welche dieselben bilden: *Chaetoceras, Rhizosclenia, Skeletonema, Microcystis, Anabaena, Prorocentrum.* u. a. des Phytoplanktons; *Synchaeta vorax* und *baltica*, übliche Süsswasserrotatorien und die pontokaspischen Centropagiden (*Evadne* und *Cercopagis*), sowie *Acartia latisetosa* und *A. clausi* u. a. des Zooplanktons; Tubificiden, Chironomidenlarven, Hypania, Cardium, Syndesmya, Hydrobia, Gammariden, Cumaceen u. s. w. des Benthos — sind Formen, welche hier eine grosse Entwicklung erreichen und z. T. in enormen Mengen auftreten, namentlich in den der Nord- und Ostgrenze des Meeres naheliegenden Gebieten.

Die Ichthyofauna des eigentlichen Asowschen Meeres mit den Flussmündungen mitgerechnet setzt sich aus insgesamt 115 Arten zusammen, von denen 82 im Meere vorkommen. Zählt man jedoch dabei die seltenen oder nur im Süsswasser, oder umgekehrt nur vereinzelt vom Meere her einwandernden Arten nicht mit, so erhalten wir die eigentlich typische Asowsche Fischfauna aus 58 Arten bestehend, von welchen 18 anadrome Formen, welche regelmässig zum Laichen die Flüsse heraufsteigen, sind und zwar: *Huso huso, Acipenser nudiventris, A. güldenstädti, A. stellatus, Caspialosa tanaica, C. pontica, Cyprinus carpio, Pelecus cultratus, Vimba vimba, Blicca björkna, Abramis brama, A. sapa, A. ballerus, Alburnus chalcoides, Aspius aspius, Leuciscus frisii, Rutilus rutilus heckeli, Lucioperca lucioperca.* Die einzelnen Arten verhalten sich natürlich verschiedenartig gegenüber dem Salzgehalt, der Temperatur und anderen hydrologischen Verhältnissen. Die Ernährungsverhältnisse der Fische sind im allgemeinen recht günstig und zwar nicht nur für die typisch Asowschen Fische, sondern z. T. auch für einige, welche aus dem Schwarzen Meer speziell zur Ernährung zeitweilig hierher wandern. Der jährliche Fischereiertrag des Asowschen Meeres und der in dasselbe einmündenden Flüsse betrug 1913 ca. 33,500 Tonnen.

Eine Anzahl Tabellen, Karten und hydrologische Profile erläutern diese grossangelegte und gegenwärtig für das Asowsche Meer einzig dastehende Arbeit.

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Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. Allen's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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